

FINAL REPORT

ENERGY USE IN LOW-INCOME DWELLINGS  
IN THE WINTER RAINFALL AREA

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**TITLE:** Energy use in low-income dwellings in the winter rainfall area

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## EXECUTIVE SUMMARY

### 1. INTRODUCTION

The original objective of this study was to identify the quantity, uses and types of energy used in low-income houses in the winter rainfall area of the Cape Peninsula and to estimate the effect income has on energy consumption.

The key questions were framed as:

- (1) What are the determinants of the choice of energy used in urban dwellings?
- (2) How does income affect the energy used in urban dwellings?
- (3) What are the exhibited income elasticities of the energy used?
- (4) How does energy utilization in South Africa compare with that in other countries?
- (5) Does the type of housing affect energy consumption?
- (6) What is the energy used for, in what volume and what cost?
- (7) What is the total energy use and cost per fuel type used in second world (sic) dwellings in the Cape Peninsula.

Questionnaire surveys were conducted to answer the last three key questions. A literature survey provided information for the international comparison (key question 4). Analysis of the questionnaire data soon revealed that very poor income elasticities in energy consumption patterns (key questions 2 & 3) and in order to answer the first key question on the determinants of energy use it was necessary to explore wider socio-economic parameters.

The most useful explanatory framework was to look at the effect of urbanization on the process of energy transition or shifts in energy choices. Rather than presenting a simple static picture of energy consumption patterns, the study aimed instead to develop a dynamic model which accounts for energy use patterns.

This report thus deals essentially with the domestic energy transition process of populations that are urbanizing rapidly. Specific attention is paid to the black population component of South Africa, in particular those residing in the Cape Peninsula, although data from elsewhere in the country is also examined. In addition the process is analyzed in some fourteen Sub-Saharan African countries.

The energy transition process is defined as the process whereby the energy consumption patterns of fuels used by a population change over time. The urbanization process is defined as the process whereby the population of a nation or geographical unit becomes progressively more concentrated in urban places and progressively less rural, and in so doing undergoes a process of modernization that is rapid in relation to the rural periphery.

### 2. LITERATURE SURVEY

The literature survey indicates that the link between urbanization and modernization, originally considered to be both causal and axiomatic, is now being questioned - particularly in Africa. Third World urbanization is being increasingly interpreted in terms of the

"underdevelopment paradigm" whereby it is postulated that European expansion from the sixteenth century onwards transformed the Third World.

African urbanization is considered to be a special subset of Third World urbanization. Sub-Saharan Africa is historically one of the least urbanized regions of the world but is now urbanizing extremely rapidly. African urbanization is unique in that "most migrants in cities intend to return eventually to their rural homelands, in sharp contrast to the situation in many other world regions" (O'Connor, 1983:68). In addition, the demographic transition of falling fertility rates, associated with urbanization elsewhere, is not yet happening. Mabogunge (1986) points out that in Africa urbanization has failed to improve the lot of the majority of the population and coins the term "backwash urbanization" to explain the process which is driven by inappropriate economic policies of the countries in question.

In South Africa the process has been influenced by the policies of influx control and industrial decentralization. An underlying hypothesis in much of the literature on the process is that the process is dependent on in-migration to the cities whereas natural increase is the dominant factor in urban growth. Focussing more narrowly on informal settlements it appears that these will be the dominant element of urban growth in the future. The permanency of these settlements is revealed in the few studies in these areas in South Africa, as is the major role played by the informal sector. At present migration appears to account for only one third of the growth rates of these areas. Intra-urban migration however results in high growth rates in certain areas. The spatial aspects of the demand for energy will be largely dictated by the patterns of growth of these settlements. In terms of electrification the Brazilian example should be noted where some 70% of the informal settlements are electrified.

The literature survey indicates that the domestic energy transition process has only recently become the subject of investigation. The importance of the process to developing countries is due to the share the domestic sector has of total commercial energy demand (up to three quarters in the poorer countries), the rapid increase in fossil fuel usage and the high income elasticity of electricity. In spite of this perceived transition, macro-level studies of several countries reveal the intransigence of the subsistence sector to change in fuels used. This is particularly a problem in Sub-Saharan Africa which contains the countries with the highest proportions of traditional fuel use.

At the macro-level the link between economic development and the energy transition process is reasonably clear. Certain broad indicators of development, notably levels of industrialization and urbanization, are well correlated with energy consumption. The choice of fuels is however at the core of understanding the energy transition process. Some understanding of the number of factors that influence choice of fuels is gleaned from the micro-level studies. Household economic characteristics - income, expenditure and wealth; household social characteristics - age/sex composition, sex of household head, labour divisions; built environment factors - size and type of dwelling; climatic factors, characteristics of the fuels - convenience, safety, odour and the stock and characteristics of appliances are one set of factors. Another set of factors relates to the prices of fuels. Here it is unclear whether actual prices, prices



per useful energy unit or perceived relative prices are dominant in the price signalling mechanism. The number of factors accounts for the large variability of energy consumption among households reported in the literature.

In Africa, at the micro-level, there are indications that an energy transition process is underway. This process is largely confined to the cities where the lack of access to traditional fuels is as significant factor in the process and is thus linked to the urbanization process. The transition is away from traditional fuels to paraffin, gas and electricity. In South Africa traditional fuels still supply a large proportion of the rural household energy budget. The degree of commercialization of woodfuel is however high - indicative of shortages. In addition there is a high penetration of paraffin in the rural areas. In the peri-urban areas of South Africa the incidence of woodfuel usage is still high but in the urban areas it is low. In these areas the dominant fuels are coal and paraffin.

The literature survey reveals an underlying economic determinism in the approach to the analysis of the energy transition process. At the macro-level fuel price and income levels are the two factors used almost universally. At the micro-level additional factors are often introduced but the model is still economic. The spatial dimensions for the demand for energy are rarely mentioned, or subsumed under the general heading of "urbanization". The underlying demographic variables that influence energy demand are often dealt with in the same way.

### 3. THEORETICAL FRAMEWORK, RESEARCH METHODOLOGY AND SURVEYS

Consumer theory offers a theoretical framework within which energy transition may be explained. Consumer theory has two components - the economic and the behavioural. Both components of consumer theory attempt to explain acts of choice, of a consumer or household, at a given time or over a period of time. Consumer theory however has significant drawbacks when applied to the Third World.

To analyze the domestic energy transition process three fundamental questions have to be answered. Firstly which fuels will be used. Secondly what quantity of these fuels will be used. Thirdly, at what rate will fuels be substituted.

Cross-sectional data both at the macro and micro scale, adequately answers the first two questions. The third question however introduces the element of time which is effectively only dealt with by time-series data. The short span over which data for this dissertation was collected ruled out obtaining time-series data. As a result, the rate of fuel substitution has to be inferred from comparisons of micro-level cross-sectional data and correlations with time related socio-economic variables. In addition this rate may be obtained by broadening the scope to include the use of macro data to allow comparisons between countries, and by using time-series market research data within South Africa.

The broad hypotheses tested in this study are as follows:-

- 1) There is a process of change of fuel usage by the black population that can be discerned over time and space and this energy transition

process can be partially explained in terms of a variety of socio-economic variables.

- 2) The energy transition process is a function of modernization and not simply the geographical aspect of urbanization. i.e. The process is not a function of population movement alone.
- 3) The energy transition process differs between rural area, town and metropolitan area.
- 4) The energy transition process is a function of choice within a given budgetary and behavioural framework.
- 5) The role of economic factors in the process gives way to social and behavioural factors as incomes increase.
- 6) The commercialization of energy resources and the efficacy of the distribution systems of these resources play a fundamental role in determining the nature of the transition process.

The research methodologies adopted were the collection and collation of existing data at the macro-scale, and the study of specific areas by means of structured interviews at the micro-scale. A project entitled "Energy use in low income dwellings in the winter rainfall area" was commenced (not by the author) under the auspices of the Energy Research Institute at the University of Cape Town in 1987 and 1988. This project consisted of a sample of 553 interviews conducted in 1987 and 1988. This sample formed the initial basis of the micro-scale investigation but much of the data could not be used due to substantive errors revealed in the follow-up survey.

The "follow-up" survey consisted of 67 interviews conducted in an informal settlement in the Transvaal in 1988, and 180 interviews conducted in the formal and informal areas of Greater Cape Town in 1988/89. In addition the distribution networks of woodfuel, paraffin and gas were the subject of three brief questionnaire surveys. Finally the electrified households of Langa and Gugulethu formed the basis of an in-depth survey of electricity consumption patterns. The experimental design of this survey was constrained by the necessity of backchecking the original survey. As a result the questionnaire used in the initial survey dictated a core of questions to be followed in the subsequent surveys to allow for the validation of the initial data. This meant that the research method of structured surveys was adopted partially by default.

#### **4. ENERGY CONSUMPTION AND TRANSITION IN SOUTHERN AFRICA: ANALYSIS OF EXISTING DATA**

##### **A. SUB-SAHARAN AFRICA**

The macro-economic indications of the energy transition process in 14 Sub-Saharan African countries were investigated. Both fuel related and socio-demographic data were used. While the sample is small the results suggest that in Sub-Saharan Africa there are indications of an energy transition process. This process is the shift away from woodfuel to the use of paraffin and electricity. The process is influenced by both urbanization level and the level of economic development of a country (as measured by GNP/capita) but does not appear to be influenced by the rate of growth of the GNP per capita. The population growth rate and the urban growth rate are closely linked and high rates of these variables stimulate the further consumption of woodfuel.

The results must be seen in the light of severe data limitations on the one hand, and a period of general economic decline in Sub-Saharan

Africa on the other. At this level of analysis the expected shift to transitional fuels, in this case paraffin, is not as significant as expected. A deeper analysis focussing on the domestic sectors of 5 countries (Kenya, Malawi, Nigeria, Zambia and Zimbabwe) suggests that the indications of energy is erratic. Firstly, woodfuel consumption increased in all the countries in question. Secondly, electricity is the fuel that posts the highest growth rates. Thirdly, of the transitional fuels, gas shows positive growth rates in only two countries. Paraffin shows no growth and in fact shows a decline in Nigeria, an oil producing country. This suggests that, in the domestic sector, where energy transition is occurring, electricity is the dominant substitute for traditional fuels. Even in Nigeria the growth in the consumption of electricity is greater than that of liquid fuels.

To further uncover the process an analysis of Zimbabwe was undertaken. In that country a large survey at the level of the household and corrected for population growth was available (Hosier, 1986). Huge differences in patterns of energy consumption between rural and urban areas are evident. In 1984 some 24% of Zimbabwe's population lived in urban areas but consumed only 6.7% of the domestic sector total net energy. There was also a striking difference in average net household consumption of energy between the affluent "low-density areas" (31GJ) and the poorer "high-density areas" (18GJ). Woodfuel is critical throughout the domestic sector. Energy transition is an urban phenomena with coal as the transitional fuel in "high-density urban areas and electricity in the "low-density" areas. The consumption figures of paraffin and gas are very low. Based on frequency and consumption figures from a different source (Harlen & David, 1983) however there are indications that a major unnoticed transition to paraffin could be taking place.

## B. SOUTH AFRICA

The major data sources within South Africa were Bureau of Market Research (BMR) reports and various energy studies.

The BMR studies report household expenditure in a "fuel & light" category which is however not inclusive of electricity. As certain areas have been sampled over a number of years time-series data analysis is possible which indicates that although erratic, there has been a decline over time in the relative expenditure on fuel and light in the urban areas. In addition the relative budget share in this category is higher in rural areas in any one time period. In the homelands the expenditure on wood decreases in relation to the level of urbanization of these areas. Paraffin is the major fuel in the wholly rural areas while coal is the dominant fuel in the towns and metropolitan areas. There is an relationship between paraffin and coal use in the metropolitan areas. A BMR survey of Cape Town in 1972 disaggregated fuels by end use and income. This study indicates that the use of fuels for cooking and heating is strongly influenced by income.

The last decade has seen an increasing number of South African energy studies which focus attention on the use of energy by the populations in question. In all the studies reported use is made of several fuels simultaneously. The broad pattern revealed by these energy studies is that of widespread commercialization of fuel wood in the rural areas and widespread use of paraffin. In the urban areas paraffin and coal are the dominant fuels and commercial fuelwood and

gas minor fuels. Taken as whole these energy studies confirm the rural urban differences and the regional differences highlighted by the BMR data but no time-series analysis is possible. Indications of the energy transition process are thus unexplicit.

From the study of domestic energy transition in South Africa at the national scale a number of tentative conclusions may be drawn.

Firstly, a division between coal and paraffin dominated regions may be made. This gives rise to the question as to whether the cost of coal in relation to paraffin, or some other variable, dictates the relationship between the use of these two fuels. As the relative share of coal in the household fuel budget falls in relation to the distance from the Transvaal coal mines, reflecting the high transport cost component of the fuel, a strong case can be made that the price variable is dominant.

Secondly, while there are wide ranges in the data, there are definite differences between rural and urban energy use patterns. In the former areas fuelwood plays a large role although it is not generally the dominant fuel in terms of expenditure. In the urban areas paraffin and coal are dominant.

Thirdly, the domestic energy transition process has developed further in the black population of South Africa than in other Sub-Saharan African countries. In the rural areas of South Africa commercialization of woodfuel and the use of paraffin is extensive while in the urban areas transitional fuels are dominant.

## 5. ANALYSIS OF THE FOLLOW-UP SURVEY: SOCIO-ECONOMIC DATA

The follow-up survey covered the older formal areas of Langa, Gugulethu and Nyanga, and the new formal areas of New Crossroads and Khayelitsha village. The old informal areas of Old Crossroads and sites B and C of Khayelitsha, and the various new informal areas are also covered. The data was disaggregated into these area groups wherever possible.

The socio-economic data collected indicates significant differences in family size, average age, income, expenditure and employment, and in fact in all the variables listed, between the four categories of areas (and also the Transvaal). In terms of urbanization and the urban economy the areas have different functions. The informal areas are acting as the overflow for the growth and family formation of the black population of Greater Cape Town. In addition the "influx" of migrants from rural areas is to these informal areas. The evidence relating to poverty is somewhat contradictory. The household incomes are lower in the informal areas but the per capita incomes are similar to their formal counterparts. In the informal areas the ratio of expenditure on food and clothing to total household expenditure is higher, and car ownership per household is lower - both indicative of a higher degree of poverty in these areas. Paradoxically, discretionary income per household appears to be higher in the informal areas. This also calls the reliability of the income and expenditure data into question.

These differences are vital in the search for clues to the energy transition process as they allow cross-sectional comparisons between different groups of the sample population to be made. However, a

correlation analysis of socio-economic variables indicates that multi-collinearity is a major problem as each of the variables is dependent on the others to some extent.

## 6. ANALYSIS OF THE FOLLOW-UP SURVEY: FUEL RELATED DATA.

The survey revealed that multiple fuel use is the norm. In terms of incidence of use and average household expenditure per fuel paraffin is the dominant fuel in the Cape while coal is dominant in the Transvaal. The usage of wood was almost absent in the Cape while in the Transvaal it is used as kindling for coal. The high proportional expenditure on gas in the new formal areas of the Cape and the high usage of gas generally is significant. The percentage of household income devoted to fuel ranges between 7% and 11% but as a percentage of expenditure the range is much wider - from 7% to 22%.

On a per capita basis substantially more paraffin is used in the informal areas while more gas is used in the formal areas. There is a marked difference in useful energy used per household, ranging from 424 MJ per week in the old formal areas to 175 MJ per week in the new informal areas. An analysis of useful energy costs of each fuel indicates that there are only small differences in these costs; paraffin averages 3,2 c/MJ, electricity 3,5 c/MJ and gas 3,6 c/MJ.

The analysis suggests that if there is a relative shift of population from informal to formal areas an energy transition process will occur with a substitution of electricity and gas for paraffin and coal. Gas appears to have a special role as it allows continued consumption in spite of the use of electricity.

## 7. INTERRELATIONSHIPS BETWEEN FUEL VARIABLES AND SOCIO-ECONOMIC VARIABLES

The relationships between the fuel and socio-economic variables that are revealed are complex. The multi-collinearity of the socio-economic variables is partly the cause. The small sample sizes and the limitations of using mainly non-parametric techniques reduce the clarity with which relationships can be distinguished even further. In spite of this a fundamental conclusion, that fuel expenditure is not generally influenced by income, may be drawn. Fuel expenditure, which is an element in the energy transition process, appears to be influenced primarily by modernization, of which time urbanized and residential mobility are two components.

Disaggregating the whole Cape sample into groups allows the examination of the behaviour of each fuel (exclusively) in more detail by controlling the grouping variable. When grouped by dwelling type the most significant variable in the informal areas is residential mobility which is a measure of social stability. When broken down further into the area groups the pattern becomes confused. Total household expenditure however does emerge as an important variable for the lower income group when grouping by income. Income itself becomes important for the newly urbanized when grouping by time urbanized. Only in the last mentioned grouping is there a pattern of increasing fuel expenditure for all fuels. Throughout all groupings household size has a pervasive influence, suggesting that per capita fuel consumption within households is an important factor. This variable should however be seen as a component

of household type which is also influenced by the ages and sexes of the family as well as the sex and marital status of the household head.

The analysis of multiple fuel use is attempted by forming multiple fuel groups that are defined on the basis of the dominant fuel having more than 75% of total household fuel expenditure. A clear pattern of increasing values for all the socio-economic variables across the groups is found suggesting that the energy transition process may best be explored in term of multiple rather than individual fuel usage.

The paraffin group emerges as a group solely dependent on paraffin and making up more than half the whole Cape sample. This large group can be described as the newly urbanized urban poor. A dramatic increase in expenditure between the paraffin group and all three other fuel groups suggests that the energy transition process is one of rapid adoption of new fuels and the slow abandonment of the old ones.

From the correlation analysis it is evident that fuel expenditure can be determined by ascertaining changes in covarying socio-economic variables with varying levels of accuracy depending on the group and sample chosen. Due to the close relationship of expenditure on fuels and consumption of fuels, corroborated by the brief analysis of consumption variables and consumption ratios, it is thus possible to forecast static demand within these limits of accuracy. However, the understanding of the energy transition process requires understanding the dynamics of the choice of mixes of fuels. The brief analysis conducted indicates that this choice of fuels cannot be accurately predicted in terms of the socio-economic variables used in the study.

## 8. ATTITUDES, APPLIANCES AND ADDITIONAL SURVEYS

The survey reveals a positive attitude towards the convenience of electricity and the economy of paraffin. Conversely negative attitudes towards the expense of electricity, the dirtiness of paraffin and the danger of gas prevail. While not necessarily so paraffin is perceived as being the cheapest fuel.

In terms of appliances, lighting and cooking appliances are universal while the ownership of fridges ranks lowest. In terms of cost there is an order of magnitude between the investment required for paraffin appliances as opposed to gas and electrical appliances.

The short surveys of the vendors of some of the fuels used gives additional insight into the distribution networks. Wood is now used as a specialist fuel, for commercial cooking purposes, and some wood was for sale. The paraffin distribution system is large and extends from the level of the large supermarket, through the shopping centre shop down to the shack shop and individual dwelling where small amounts are bottled for sale. The gas distribution network is the most commercial, with capital investment by the suppliers and indications of retail price maintenance. The price survey indicates that the effect of the distribution system on increasing the net energy price of fuels is substantial.

The electricity survey reveals that income is not correlated with the amount of electricity used. There is however a correlation with income per capita and per employee and the outstanding balance owing, suggesting that the debt burden is income elastic.

## 9. THE ENERGY TRANSITION PROCESS

The domestic energy transition process seen as a whole is one of the complete substitution of biomass fuels and the progressive adoption and abandonment of transitional fuels before the final stage of complete dependency on electricity is reached. The process is dynamic and varies both temporally and spatially. The process is driven by the search for greater amenity and economy within the framework of the family budget. While certain specific variables explain part of the process it is stochastic with a variable random component.

The process can be described in terms of fuels used and the socio-economic characteristics of the population at a particular stage in the process. It should be noted that there is a discontinuity between the rural and urban components of the process, namely the urbanization process. Six distinct phases can be identified. These are a biomass dependency stage, a rural transition phase, three urban phases and a final stage of total dependency on electricity.

Modernization governs both the economic and behavioural aspects of the energy transition process and the process may be measured in terms of a modernization index. As income appears to be only a secondary variable the standard approach of calculating income elasticities was not followed.

The energy transition process has various policy implications. A rural policy to reduce the dependence of these areas on woodfuels is a necessary part of the general economic upliftment of these areas. An urban energy policy of domestic fuel price independence and an energy policy for formal and informal housing is suggested. In addition the leasing of appliances should be investigated, as well as technical assistance to the black local authorities.

## 10. CONCLUSIONS

The major conclusions of the study are as follows:-

### 1. Data and scope.

With respect to the data collected at the micro-level in this study it is apparent that the sample is too small. Larger samples would improve levels of confidence and permit the use of parametric techniques. In addition larger samples would permit grouping and sub-grouping to be performed with sub-samples of reasonable sizes. Much could be learnt about the final phases of the energy transition process by broadening the scope to include other population groups.

### 2. Urbanization

South African urbanization as a type is akin to African urbanization generally. In spite of this the governing paradigms regarding this process are still Eurocentric. The "backwash urbanization" of Mabogunge (1986) could be used to explain the absorption of the urban growth by the informal sector but the vital questions as to how urbanization influences economic welfare and modernization are largely unanswered. Whether the existing high level of urbanization and economic development in South Africa will allow rapid

modernization and consequently rapid domestic energy transition remains to be seen. This presupposes a shift from informal to formal dwellings and sectors whereas the opposite is occurring in the metropolitan areas.

The literature survey provides ample evidence that there is a link between urbanization and energy transition. The most profitable avenue of further research on the energy transition process is the identification and estimation of the spatial aspects of this link. Population shifts to the urban areas and natural growth are one aspect of this. The rates of movement between formal and informal areas within urban areas are another.

### **3. Macro vs Micro**

From the literature survey the links between energy transition and economic development at the macro-level are clear. The clarity at the macro-level is however not carried through to the micro-level. At this latter level there is a pervasive economic determinism in the face of much evidence that non-market forces are the dominant factors. The findings of this study are similar. Here the energy transition process is found to be more easily detectable by cross-country and rural/urban comparison than at the micro-level. The problem is not simply the variability of data at the latter level but the fact that only cross-sectional data is available. However, the case of Zimbabwe with huge differences in net energy consumption between three sets of data for the same year, indicates the basic unreliability of macro data in Sub-Saharan Africa. Until this reliability improves answers will thus have to be found at the micro-level. Here again this abovementioned case indicates that elements of the energy transition may be ignored or misinterpreted from micro-level investigations if attention is not paid to detail.

### **4. The energy transition process in Sub-Saharan Africa.**

The linkage of economic development, as measured by GNP per capita, and type and consumption of fuels, is revealed in the macro-level investigation of selected African countries. It appears that the relationship between total population growth and the growth of woodfuel consumption will result in the inevitable increase in the dimensions of the "woodfuel crisis". In these countries energy transition is an urban process. The level of urbanization in these countries is positively related to the per capita consumption of paraffin and electricity, and negatively to woodfuel. The rate of urban growth is however associated negatively to the per capita consumption of electricity. The implication, that burgeoning cities cannot keep up with the requisite rate of electrification applies equally to the South African experience.

### **5. A comparison with Zimbabwe**

Zimbabwe may represent phases of the energy transition process through which South Africa has already progressed and through which some regions (such as the homelands) may still have to go. Zimbabwe reveals large differences in energy consumption patterns between rural areas, high density and low density urban areas. In the high density areas, similar to the South African informal areas, electricity accounts for a 60% of the useful energy consumed by households while woodfuel still accounts for 20%. In the informal areas of the Western Cape paraffin accounts for 70% of the useful



energy consumed and gas the remainder but in spite of no electricity these areas consumed on average 50% more useful energy than their Zimbabwean counterparts. This suggests that useful energy consumption is related to the level of economic development regardless of the fuels available.

## 6. Domestic energy transition in South Africa - the existing data.

An analysis of the Bureau of Market Research (BMR) of UNISA research reports

since 1977 provides a cross-sectional and time-series picture of the domestic energy transition process. For the period in question the budget shares of household expenditure of the fuel and light category were always higher in the rural areas than in the urban areas. There was a relative decline in this category over time in all the urban areas while it remained static or even increased slightly in the rural areas. In addition, when disaggregated into fuel groups, there was an decrease in the use of wood as the relative urbanity of these rural areas increased. In these rural areas paraffin was in 1977 already the dominant fuel in terms of expenditure. All of these indicate that a process of energy transition has occurred over time but that, unlike the rest of Africa, this not solely an urban phenomenon. The largely static rates of fuel and light budget shares in the rural areas suggest that the energy transition process there will be a long term process in relation to the urban areas.

When dealing with these urban areas the BMR data indicates that there is a clear pattern of an inverse relationship in the average expenditure on paraffin to that on coal. As a result South Africa can be divided into a coal dominant region, a paraffin dominant region and an intermediate region where wood is still important. Although last available for 1972 for the Cape a disaggregation of expenditure by fuels and end use indicate that at that date wood was already a minor fuel and paraffin was dominant. Comparing this data to that of the follow-up survey the domestic energy transition in this area has been from coal to gas while paraffin has remained the dominant fuel.

The BMR reports and various energy studies indicate that multiple fuel use is the norm and this is corroborated by the follow up survey. The energy studies, largely conducted in the rural areas, indicate that multiple fuel use extends to the rural areas where wood now forms between 20% and 50% of the household fuel budget. This indicates that a major transition to commercial wood purchasing has taken place but no rate of substitution can be calculated.

## 7. The socio-economic data of the follow-up survey.

The findings relating to the socio-economic characteristics of the sample populations of the follow-up survey are in many ways as important as those relating to fuel. Differences in age, household size, time urbanized, and other characteristics indicate a fundamental difference in function between the new and old formal and informal areas. The new informal areas that are the fastest growing are the catchment areas for both newly arrived rural-urban migrants and the overflow from the old formal areas. These wide differences in characteristics and function permit the regrouping of the sample but the correlations between most of the socio-economic variables reveal that multi-collinearity prevents the isolation of the influence of a single variable. Much more research is required to unravel the effects of these variables on each other.

## 8. The fuel data of the follow-up survey.

A much greater usage of gas and electricity in the formal areas than in the informal areas is revealed by the study. This in itself is an indication of an incipient energy transition in the move from informal to formal. Also revealed is the difference in the budget share of fuels. In the formal areas these range between 7% and 8% while in the informal areas of the Cape and the Transvaal the range is from 18% to 22%. On the other hand the share of energy as a proportion of household income had a small range of between 7% and 10.5% with the formal areas being at the upper end of the range. This indicates that the importance of fuel is best understood in terms of total household expenditure rather than income. The non-linear relationship between income and expenditure and the influence of family size explain these differences. Both these aspects require additional research as their influence is pervasive.

The study reveals that useful energy consumption is a far more powerful analytical tool than net energy consumption. Large differences of this quantity between the areas were found. These reflect the different efficiencies of the appliance sets of these areas. Another aspect highlighted in this study is the close similarity of average costs of all major fuels when calculated on a useful energy basis. This raises the important question as to whether price plays a role in the choice between fuels.

## 9. The interrelationship of socio-economic and fuel variables

Unlike at the macro-level no strong relationships between the fuels themselves were found, apart from between coal and wood in the Transvaal sample. This suggests that the process of energy transition does not involve the simple substitution of one fuel for another.

The heart of the analytical phase of this study is the establishment of the relationships between the socio-economic variables and the fuel variables. No simple pattern was immediately apparent, probably as the result of multicollinearity. However certain variables emerged repeatedly as different groups were formed, while others remained absent. An important finding is the lack of influence of income on fuel expenditure. This absence was most noticeable in the formal areas. The most pervasive variable is the time urbanized. When regrouped in terms of this variable there is an increase in expenditure with time urbanized for all of the fuel groups.

When dealing with fuels as groups, it is apparent that on the basis of categorization by dominant fuels paraffin is the sole fuel for over half of the Cape sample with the mixed fuel group following. This is an indication of the extremely important role that this fuel plays in the region.

## 10. Attitudes and preferences

Electricity is seen as being convenient, paraffin as being economical and gas as being clean. Although electricity is perceived as being expensive it is the preferred fuel, particularly for those who do not have it. These attitudes and preferences are fundamental as the perceptions lead to choices of appliances and multiple fuel use, such as the general case of paraffin heating in electrified homes. As indicated the range of useful energy prices for various fuels is

small and hence it appears that perceived rather than actual prices are important in the choice between fuels. The cost of appliances is another vital factor in the energy transition process. Stoves and lights, which are necessities used by all in the survey, cost less than a tenth if they are paraffin as opposed to gas appliances. Electrical appliances can cost even more. A further factor, not explored in this study, is the diffusion process with regard to appliances.

#### **11. The woodgatherers and fuel vendors**

The very low level of wood use in the Cape revealed by the survey is a significant finding. The survey of woodgatherers indicates that wood is now a specialist fuel for food merchants in the townships and that its use is not domestic. The survey also revealed that woodgathering was a hazardous, arduous, time consuming occupation that brought in very little revenue. In addition the theoretically free access to the undeniably extensive wood resource was in practice constrained by traffic police and land owners. In the light of these considerations it is small wonder that there has been a transition away from wood to paraffin.

The brief surveys of the paraffin and gas merchants indicate an extensive formal and informal system distributing these fuels in the black areas of the Cape and the Transvaal. This distribution system plays a major role in determining not only the access of consumers to fuels but also the final retail prices. Investigation of these distribution systems is a profitable line for further research.

#### **12. The electricity survey**

An additional survey of the electrified households in the Cape sample indicates that the transition to electricity is by no means complete. The households in the sample consumed on average some 30% less electricity than the average for the whole Cape. Multiple fuel use was found in over half the sample and, on average, electricity accounted for only 66% of the total fuel expenditure. That the adoption of electricity is not unproblematic is highlighted by the fact that the households in the sample were 17 months in arrears on average. A significant finding is that the income of households is not correlated with consumption. There is however a negative correlation between per capita income and the outstanding balance.

This study reveals clearly that the energy transition process does not stop with electrification. This fuel has to go through an adoption phase and the subsidiary fuels have to be abandoned before the final stage of sole dependence on electricity is reached. This study indicates that how long this takes is a function of the process of modernization rather than simply the increase in the level of income.

#### **13. The domestic energy transition process**

To synthesize the analysis a model of the domestic energy transition process is presented. Six phases of the process are identified - from biomass dependency through rural transition and three urban transitions to a final stage of sole dependency on electricity. The choices between fuels and increasing consumption of useful energy is explained in terms of the modernization paradigm presented. The level of modernization influences the attitudes and preferences towards

fuels and the rate of diffusion of new appliances. It also influences the budgetary constraints of the consumer as a secondary effect through influencing income.

Within the paradigm of modernization the domestic energy transition process cannot be adequately understood outside of the framework of the household budget. While expenditure on energy increases in monetary terms as incomes rise the relative importance of this item declines. Household budgeting decisions are not well understood, especially at the lower end of the scale, but require clarification before the domestic energy transition process can be adequately modelled. Dealing with the household budget as an entity will however increase the data to be collected with consequential increased cost and complexity.

At this stage of the analysis, and with limited data, the descriptive model of the domestic energy transition process is the most complete model available. With further research socio-economic variables that correlate better with fuel choice and consumption could be found and a dynamic predictive model of the process developed. The outline of such a model is indicated in Appendix 5. The description of this hypothetical model suggests that at this stage the major improvements in quantifying energy demand are at the macro-demographic level concerning population shifts and housing.

#### 14. Implications

From an understanding of the process a number of policy implications flow which are set out above. One overarching implication emerges. This is the urgent need for an urban energy policy that is part of a coherent national energy policy that considers all fuels on an equal basis.

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## CHAPTER 1

### INTRODUCTION

#### 1.1 INTRODUCTION

Urbanization involves fundamental shifts and changes in the fabric of countries and regions; not least in their economic, social and demographic structure.

The metropolitan areas of South Africa are visibly undergoing rapid expansion. This expansion now consists primarily of informal black settlements on the periphery, immediately recognisable by the ubiquitous tin shacks, and to a lesser extent formal housing - usually as extensions to existing black townships. The process of urbanization within the context of which this urban expansion takes place is a complex and often misunderstood phenomenon. Even rapid urbanization is measured in decades rather than years and is an uneven process both temporally and spatially.

Concomitant with urbanization is the process of energy transition whereby, as a society modernizes, energy requirements increase and different energy sources are relied upon. Understanding this transition is essential for forecasting energy requirements and formulating energy policy, as are an understanding of the determinants of the rates and forms of urbanization. Little work has however been undertaken, both internationally and locally, on energy transition among the newly urbanised and urban poor. A need thus exists in South Africa for a study of this process within the context of rapid urbanization.

#### 1.2 PRELIMINARY DEFINITIONS

Both urbanization and energy transition are social processes that take place over time and within the context of a space economy. The length of time and size of the space economy may vary but the core concepts of the definitions given below remain valid.

##### 1.2.1 Energy Transition

Energy transition is the process whereby the energy consumption patterns of fuels used by a population change over time. The population under study may vary in size from a country down to a small region or village.

Energy resources are used differently over time, with new fuels replacing traditional ones and, generally, the intensity of use of energy increasing over time. This trend is affected by a host of factors ranging from macro-economic conditions to the efficiency of energy using appliances. In addition to varying over time the use of energy resources varies sectorially over the population and hence energy transition may also be studied as a parallel process of social change.

Key problems with energy transition are the definition and measurement of "traditional" energy resources and establishing which societal factors influence the transition. The time-scale over which the process is studied is of importance as the influence of short term phenomena and seasonality cloud observations taken over a short period. As a result time-series observations over a longer period are likely to yield more information on the process than short term time-series and cross sectional data. The term 'energy transition' is preferred to 'fuel substitution' which has short term connotations.

### 1.2.2 Urbanization

Urbanization is defined herein as the process whereby the population of a nation or geographical unit becomes progressively more concentrated in urban places and progressively less rural, and in so doing undergoes a process of modernization that is rapid in relation to the rural periphery. The definition thus embraces both a geographical aspect and a social process. The smallest geographical unit to which the definition may be applied is that which encloses both the urban and rural components of a city-rural system.

A key problem in the definition is the concept of 'urban places', i.e. what constitutes a 'town' or 'city'. This problem is of particular relevance to South Africa where some rural densities in the 'homelands' are higher than suburban densities. A further problem is the popular confusion of urban growth with urbanization. High rates of urban growth may be recorded while urbanization rates are low, and vice versa.

"Rapid" or "accelerated" urbanization are two terms encountered with increasing frequency. Both terms are intended to convey a period wherein the geographical aspect of urbanization is more rapid than the norm. Taken as a whole the rate of urbanization in South Africa is low, some 3% per annum, in relation to the remainder of Sub-Saharan Africa where the rate ranges from 5% to 15% per annum. Urban growth however is rapid in South Africa.

### 1.2.3 Formal and Informal Areas

The rapid growth of South African cities has taken place largely in what were until recently termed "Squatter Camps". Of late the term has gone out of vogue and been replaced by the somewhat less perjorative "informal" area, with echoes of the word as used to describe the "black" economy in SA. The antonym "formal" is used to describe the older areas with predominantly brick

dwellings. The word "peri-urban" is sometimes used in the Cape but not in the Transvaal where the term is synonymous with the Transvaal Board for the Development of Peri-urban Areas.

The rapidity of the growth of the informal areas of the Western Cape are dealt with in chapter 5 but it should be borne in mind that this growth has outstripped the provision of both housing and services, of which electricity is but one. The dynamics of this growth have a major bearing on the spatial and quantitative demand for energy, both of which are the subject of this dissertation.

### 1.3 PURPOSE

The purpose of this dissertation is the study of the process of energy transition in South Africa in the context of rapid urbanization.

### 1.4 SCOPE

The scope of this dissertation is limited to that sector of the South African population that is undergoing the process of rapid urbanization at present; viz. the African population. The scope is further reduced to focus on the domestic fuel sector of the abovementioned population group. Spatially the study focusses at the micro-level on the Western Cape but also includes data from the Transvaal. At the macro-level South Africa is the focus but the scope has been broadened to cover selected Sub-Saharan African countries for purposes of comparison.

As in all studies of this nature the scope has also been limited by the exigencies of time and money.

### 1.5 OBJECTIVES

The practical objectives of this study are as follows:-

- i) To research local and national literature on the energy transition process.
- ii) To research national and local literature on the urbanization process.
- iii) To research available data and investigate the macro-economic dimensions of the energy transition process.
- iv) To undertake primary research to investigate patterns of domestic energy usage amongst urban black households, with particular reference to the Western Cape.
- v) To investigate the growth in energy amongst urban black households.

- vi) To investigate the determinants of the various fuels used by the abovementioned households.
- vii) To investigate the intensity of energy usage in the abovementioned domestic sector.
- viii) To investigate the distribution systems of the fuels in question.
- ix) To describe the energy transition process in detail.
- x) To suggest policy implications of the findings of this study.

Central to achieving objectives iv) onward is the "follow-up" survey. This interview survey, described in detail in chapter 3, was conducted in the formal and informal areas of the black townships of greater Cape Town, and an informal area in the Transvaal, in 1988/89. There were a total of 257 respondents in the survey. Data relating to both socio-economic characteristics and fuel usage was collected and analysed as a whole and in groups, principally by non-parametric methods.

#### 1.6 ARRANGEMENT OF THE DISSERTATION

This dissertation commences with an introduction and literature survey. The research methodology is then presented. A macro-economic investigation of the energy transition process in selected African countries follows. The existing data available in South Africa is then analysed. This is followed by the analysis of the socio-economic data of the follow-up survey. The fuel-related data of the follow up survey are then analysed and correlations between the socio-economic and fuel-related data are then sought. An investigation of the attitudes of the respondents, the use of appliances and the results of the additional short surveys follow. Finally the energy transition process is described in detail, a model of energy consumption incorporating transition presented and the implications of the process to energy policy discussed.



## CHAPTER 2

### LITERATURE SURVEY

#### 2.1 URBANIZATION

##### 2.1.1 Introduction

The shifts of population during the process of urbanization result in large spatial shifts in the demand for energy. The spatial part of the process is however not a simple one. Urban areas grow by natural increase as well as rural-urban and intra-urban migration, and certain areas (the metropolitan areas in South Africa) grow more rapidly than others. Even more subtle are the changes wrought by the modernizing influence of the city over time - the social aspect of urbanization. Aspirations, attitudes and standards change and so do the types and quantities of fuels used. It is thus evident that an understanding of the process of urbanization is a precondition to understanding the process of energy transition. As urbanization is a highly complex process it does not yield to simple analysis. Nor does the energy transition process. As a result this literature survey is extensive and spans the range from international to local.

##### 2.1.2 Overview

On the subject of urbanization a large body of works exists by a disparate collection of disciplines. This eclecticism is due in part to the lack of definitional rigour regarding the subject. As Lampard (1957) wryly observes, "*Urbanization is a balloon into which social scientists blow whatever meaning they wish*". The disciplinary net is now cast wide since "...the urbanization process refers to much more than simple population growth and involves an analysis of the related economic, social and political transformations" (Drakakis-Smith, 1986). The dramatic nature of the post-war growth of cities and the urgency of the problems imposed by this growth is another reason for the proliferation of literature. For an overview of the process the reader is recommended the classic of Davis (1965) or the more recent Goldstein and Sly (1977).

The traditional approach to studying the urbanization process was within the disciplinary constraints of urban geography, sociology and economics and was inevitably Eurocentric in orientation. Until the early 60s the focus of studies on urbanization was on western cities which have a long history of steady growth. There was good reason for this as the cities of the "Third World" were as yet, with only a few exceptions, insignificant urban places enveloped by a sea of rural peasantry. The ineluctable change in the space

economies of these countries wrought by urbanization, hardly noticeable in the 50's, had by the 60's become impossible to ignore. Pioneer studies (eg Hauser, 1959) drew attention to the significant differences between the development experiences of the industrialized and developing countries. New paradigms for the understanding of the process in unfamiliar surroundings (to Western academics) were sought. The Latin American school of "underdevelopment" offers one such paradigm. In general there has been a shift of analysis away from the individual toward a class based interpretation of society and with increased attention to inequality.

### 2.1.3 Modernization

Dalton (1971:21) defines modernization as *"a sequential process of cumulative change over time, generated by the interaction of economic and cultural innovations impinging on traditional economy, polity, and society, with feedback effects on the innovating activities."* Grasping the effects of change at the macro-level is one thing and measuring it in the field is another. Adelman and Dalton (1971), describing a village in India, note that the three basic obstacles to fieldwork are the heterogeneity of the communities under study, the lack of statistical data and absence of theories of change and development at the micro level.

Inkeles and Smith (1974) developed an operational scale of individual modernity. The role of the work place is stressed, *"Employment in complex, rational, technocratic .. organizations has particular capabilities to change men so that they move from the more traditional to the more modern pole in their attitudes, values and behaviour"* (p6). The approach to modernization by these authors is socio-psychological wherein the process is a *"change in ways of perceiving, expressing and valuing"* (p16). Twenty four dimensions of individual modernity are nominated and a measure of "overall modernity" is developed. The measure was tested on 4 basic groups, cultivators, new workers, nonindustrial workers and experienced workers, in 6 developing countries. It is concluded that *"individual modernity is clearly a very broad, multifaceted phenomena"* (p105) and *"No single attribute of the person, not even how well informed he is, can stand alone as the indicator representing the whole syndrome"* (p109). Irwin (1974), on the other hand, developed an operational definition of societal modernization based on an index using energy consumption and Gross National Product.

As will be seen below the link between urbanization and modernization, originally considered to be both causal and axiomatic, is now being questioned, particularly in Africa.

### 2.1.4 Third World Urbanization

The term "Third World" originally encompassed a group of countries with similar political systems and alignments. Two important early works on

urbanization in these countries, McGee (1967) and Breese (1966) reflect the prevailing Eurocentric approach at the time wherein urbanization is considered a function of industrialisation and it is assumed that the process is likely to follow that of Western nations.

The Third World has now become an economic grouping of the poor countries of the world with a per capita income of less than US \$3000 per annum (and a life expectancy of less than 70 years). In spite of a surfeit of publications on the general topic surprisingly few urban researchers have explicitly dealt with contemporary processes of urbanization and urban growth in Third World countries. Most (eg Dwyer, 1975; Drakakis-Smith, 1981) deal with the provision of housing at the intra-urban scale, or provide a general account of the political economy of urban development. (eg Santos, 1979). Hay (1977) provides an overview of the factors influencing urbanization in the Third World and provides a statistical summary of urbanization levels in the countries in question.

Gilbert and Gugler (1981) follow the political economy approach and adopt the underdevelopment paradigm whereby, it is postulated, *"The impact of European expansion from the sixteenth century onwards transformed urban structures in the Third World. The functions and forms of contemporary Third World cities cannot be understood without a consideration of this process"* (p12). The process that results from this impact is termed "dependent urbanization", fueled by rural-urban migration which is the result of impoverishment of the rural areas. The authors do however not deal with the relative importance of migration to urban growth or the influence of circular migration on modernizing rural areas.

In a recent work Armstrong and McGee (1985) coin the term "theatres of accumulation" to emphasize the class nature of the function of Third World cities. In a penetrating analysis of Asian and Latin American urbanization based on the underdevelopment paradigm the city is portrayed as the central place where financial, commercial and industrial power is concentrated as well as centres from which western culture and values are diffused. The growing convergence in the sphere of consumption in Third World cities is juxtaposed to the divergence in the sphere of production. Empirical studies of, inter alia, Hong Kong, Ecuador and Malaysia, provide supportive evidence for the authors hypotheses that in the clash of tradition and modernity the urban setting plays a fundamental role in tilting the scale decisively toward the latter.

Potter (1985) provides a more prosaic analysis of the process and pattern of urbanization in the Third World. Urbanization is analysed in terms of classical demographic transition theory. He states *"Third World cities exemplify par excellence the combination of pre-industrial fertility with post-industrial mortality"* (p36). As a result extremely high rates of population increase are recorded and consequently *"...very often, natural increase and in-migration contribute in broadly equal proportions to*



the total growth of urban populations" (p36). Potter notes that rates of urbanization are becoming inversely related to levels of economic development while urbanization levels are closely related to levels of economic development. The rank-size rule of urban systems, so beloved by geographers, is invoked and tested empirically on the Caribbean. As with all the above authors the inequalities of the Third World cities are emphasized. Squatter settlements are dealt with in some detail and attention is drawn to "the extreme socio-economic diversity which often characterises spontaneous settlements..." (p95). One is also reminded that the Third World is not homogeneous.

Toledo (1981), in a work covering 20 squatter settlements in the four largest Brazilian cities, refers to the transient character that the authorities (as in South Africa) mistakenly attributed to the squatter settlements "...assuming that as soon as the population achieved a better socio-economic status, they would leave the precarious settlements" (p185). As in the above studies the settlements are increasingly permanent, and the household heads earn fixed wages. With regard to services he notes that, "as the low income population is neither able to pay the costs involved, nor constitute a significant demand for durable goods, their chance to have urban services available are logically reduced. The only exception is the electricity connection which is relatively low cost - thus affordable by a considerable part of the population" (p185). In Sao Paulo for example only 30% of the squatter dwellings are not served by electricity. In part, this proliferation is due to the development of informal electrical networks.

At present, on average, some 40% of the recent growth in the Third World's urban population is caused by internal migration (mostly rural-urban), with the figure rising to 70% in some of the biggest cities (Economist, 3 December 1983). This is in spite of attempts by nearly all of the countries in question to stop the drift to towns.

#### 2.1.5 African Urbanization

Urbanization in Sub-Saharan Africa is a special subset of Third World urbanization (for a short introduction to African urbanization see Peil, 1984). It is historically one of the least urbanized areas of the world but is urbanizing at an astounding rate (some 76% between 1950 and 1967 - New Scientist 4 August 1988:60). Conditions on this continent are such that food production and GDP levels have declined in almost all countries since 1960 (Economist 2 February 1985:95 & 10 September 1983:53 - see also Leys, 1987) while natural rates of population growth are among the highest in the world (Cleland and Hobcraft, 1985). In addition Sub-Saharan Africa has more extreme seasonality of poverty than other continents (Lipton, 1986), is more dependent on aid (Timberlake, 1985) and has a large and increasing debt burden (Economist 27 February 1987:74). In the face of these conditions it is not surprising that the literature on African urbanization is diverse and often contradictory.



In a pioneering work Hance (1970) investigated urban growth, and in particular migration, at a time when large African cities were still a rarity. He felt that, in terms of urban growth, *"net migration is still the predominant factor"* (p27). The impact of migration in the form of "disjunctions" between the urban and rural environments for first generation urbanites is treated in depth for West African countries. In Africa migration is often a type of long term "commuting" and the influence of returning migrants on rural areas has now attracted academic attention (see Skinner, 1985). O'Connor (1983) follows a similar (largely nonparadigmatic) schema to Hance (1970) in his analysis of the African city (excluding South Africa). He presents a taxonomy of six different types of city of which the colonial city, the focal point of underdevelopment theorists, is only one. The components of urban growth are dealt with in detail. These are natural increase, rural-urban migration, the engulfing of rural communities as cities expand and the transformation of villages into towns. With regard to natural increase he states, *"During the 1950's and even the 1960's migration accounted for a larger share in most cities, but as demographic structures have changed natural increase has become the dominant element in more and more cities"* (p53). (Cairo now grows at 3% per annum, of which 2/3 is from natural increase - Economist 2 July 1988:44).

O'Connor is unable to shed much light on the differential rates of natural increase between rural and urban areas in Africa but attention is drawn to the vital fact that in Africa the demographic transition of falling fertility rates, associated with urbanization elsewhere, is as yet not happening. The spatial and temporal patterns of migration are dealt with at length and here he concludes that, in Africa, *"Most migrants in cities intend to return eventually to their rural homelands, in sharp contrast to the situation in many other world regions.."* (p68). Rosser (1979) supports this view whereby the circulation of labour rather than its migration is an African characteristic. Ethnicity in African cities, both racial and tribal, is dealt with and the existence of "plural societies" of different value systems in these cities is analysed. In spite of urbanization agriculture has the dominant share of the GDP of Sub-Saharan African economies (Economist 2 February 1985). As far as the urban economy is concerned O'Connor notes that urban populations are expanding much faster than employment opportunities and that the concentration of poverty in cities in Africa is because *"urbanization really involves a spatial shift of such poverty rather than providing its cause"* (p131).

Mabogunje (1986) takes up this point of the failure of the process of urbanization to seriously improve the lot of the majority of the population in a work that reappraises the process within the framework of the colonial political economy and after independence. He points out that, *"Urbanization, far from being a correlate of economic development, is today the very symbol of the failure of strategies aimed at achieving that goal"* (p271). He coins the term "backwash urbanization" to explain the process. He states, *"Given the worsening economic conditions of rural*

Africa, the continued growth in the size of cities results more from the unexhausted potential of occupational and trade involution than from the conventional type of economic growth arising from functional specialization and higher labour productivity" (p268). The peasant in Africa thus finds an urban niche as a result of the informal sector rather than the formal sector. The term "backwash" is used as the process results from the backwash effect of inappropriate economic policies in the countries in question.

Stren and Letemendia (1986) corroborate Mabogunje's view, *"In the 1980s, as national economies stagnate and the 'parallel' economy accounts for more and more of the gross national product, informal transactions and exchanges are more central to economic analysis. At this point we begin to glimpse a 'ruralisation' of African cities, as they interact more organically with their rural hinterland.."* (p vi).

#### 2.1.6 Urbanization and its Elements in South Africa

##### 2.1.6.1 Urbanization

Urbanization in South Africa has a special meaning as it is through the control of population movement and the limiting of black urbanization into "white" cities that the policy of racial segregation has been carried out. Browett (in Smith, 1982) traces the process of urban containment and the evolution of unequal development. Hindson (in Tomlinson & Addleson, 1987) sets out the new approach of regional spatial ordering as opposed to traditional territorial apartheid. However, as yet no full re-examination of the process against the wider background of the peculiar political economy of the country is available.

Nattrass (1981) in her work on the SA economy deals in passing with the urbanization process. She notes that the contribution of blacks to the urban sector labour force is greater than it would seem from the level of urbanisation of that group due to the migrant labour system. She speculates *"...urbanization levels would have been very much greater had the Migrant Labour System not been institutionalized first by custom and then by the Influx Control Laws, which were specifically aimed at limiting African urban settlement"* (p14). She notes that after 1970 the system began breaking down and urban growth occurred in the form of informal areas and the increasing densities of tribal areas near the larger urban centres. Nattrass deals with migration in SA and the relationship to economic development in detail. She observes that the migrant labour system is age, sex and education specific, all to the detriment of the source rural areas where male absentee rates are as high as 70%. The stimulus to urbanize is illustrated by the fact that the homelands provided employment opportunities for only 28% of the annual increase in work seekers in the period 1973-1975. A further 37% were able to find jobs in the centre economy while the balance of 35% would become

unemployed or migrant workers.

Smit and Booysen (1981), in the the most detailed work on urbanization in South Africa to date, take a traditional approach which is basically descriptive and Eurocentric. The legal system governing African population mobility is covered in detail. The core-periphery model (see Fair and Browett 1979) is the theoretical base, with centripetal economic forces "*die samedromming van produksiefaktore in bepaalde kerngebiede of -sentrums*" and centrifugal political forces, "*die politieke emansipasie van die Swart tuislande en die staatkundige koppeling van die stedelike Swart bevolking in die 'Blanke' gebiede aan tuislande*" (p8). The historical development of Black urbanization between the poles of these forces is traced and the changing spatial pattern of development outlined whereby the increasing concentration of black urbanites into the major metropolitan areas of South Africa can be seen. The authors are somewhat uncomfortable with the phenomenon of informal settlements - "*Dit is 'n nuwe siekte..*" (p90), and make only passing reference to the influence of natural increase on rates of urbanization.

Kok and Mostert (in van Vuuren et al, 1984) take the view that "*South Africa, although not yet experiencing any urbanization problem worth mentioning, is already weighed down by its population problem*" (p99). The view is taken that urbanization is essential for socio-economic development and the "*abatement of population increase*" (p100) which is in contrast to Mabogunje's opposing hypothesis cited above. The rates of urbanization of the various races are forecast, with that of the African population estimated at 2% per annum. A more detailed analysis of the above alternative migration scenarios is given in Mostert et al (1985). The factors which influence migration in South Africa are analysed by Kok et al (1985) and Kok (1984) for Port Elizabeth. In the former study it was found that migration rates differed significantly in terms of occupation and literacy with the unemployed and illiterate having the highest ratios; "*...those persons who are probably least equipped to deal with the modern urban environment*" (p17). The youth of migrants is apparent as 30% of all migrants migrated before they were 18 years of age. Of the reasons given for migrating social reasons (family/friends) predominate at about 38% of the sample, followed by economic reasons (job/money) at 24%. It was found that some 97% of migrants moved directly to the metropolitan areas in a pattern Kok terms "primary metropolitanization". A more recent work by Hofmeyer et al (1987) found the highest incidence of migrant labour was from those areas furthest from the metropolitan areas.

With reference to the influence of urbanization on fertility levels the case of the coloured population is investigated in a HSRC study (S-N-230, 1981) wherein the 'dramatic falls in these levels over the past two decades is brought to light. While contraception was the most important single factor the influence of the social and cultural factors associated with urbanization are alluded to.



In what was heralded as a turnaround in black urbanization policy the White Paper on Urbanization (April 1986) recommended a positive urbanization strategy for the country. Dewar and Watson (1986) analyse the implications of this strategy and conclude that, *"The most disturbing feature of it, however, is the constrained and distorted way in which the 'problem of urbanization' is identified"* and thus feel that the central question of what positive urbanization means has not been addressed unambiguously (on this note see also Thomas, 1986). Bernstein (1987) addresses the response of the private sector to the positive strategy and the Abolition of Influx Control Act (1986) and states that events after the publication lead one to conclude that *"government's approach to urbanisation is still based on essential apartheid principles"* (p48). These principles include the restricting of growth of existing Black urban settlements, the continued racial segregation of urban areas, and the continued "decentralisation" of industry to peripheral homelands.

Graaf (1986) analyses the state of urbanization in the homelands. He states *"any meaningful agricultural activity has effectively ceased for larger proportions of the homeland populations.."* (p6) and a three part classification of urban areas is developed, viz; "urban", "semi-urban" and "peri-urban". This dramatically changes the picture of how many blacks were in fact "urbanized" in 1980, to 51.8% as opposed to the 41,6% of Simkins (1983) whose work is the standard reference in terms of black urbanization. In terms of projections of the black urban population Simkins (1983) projects a low figure of 52,9% (18,4 mill) and a high figure of 61,2% (21,3 mill) by 2000. This is broad agreement with Kok and Mostert (1984) who give a figure of 60% (20,7 mill).

Figure 2.1 indicates the growth of the total urban and the total rural populations from 1904 to 1985, based on census returns for the years indicated (Central Statistical Services, 1988). This figure illustrates that urbanization is based on two dynamic components - the rural and the urban. Figure 2.2 indicates the historical composition of the urban areas in terms of the various population groups since 1904. The rising proportion of the black component is clear, as is the underlying growth rate of this component.

FIGURE 2.1 URBAN & RURAL POPULATION OF SOUTH AFRICA: HISTORICAL DATA: 1904/1986

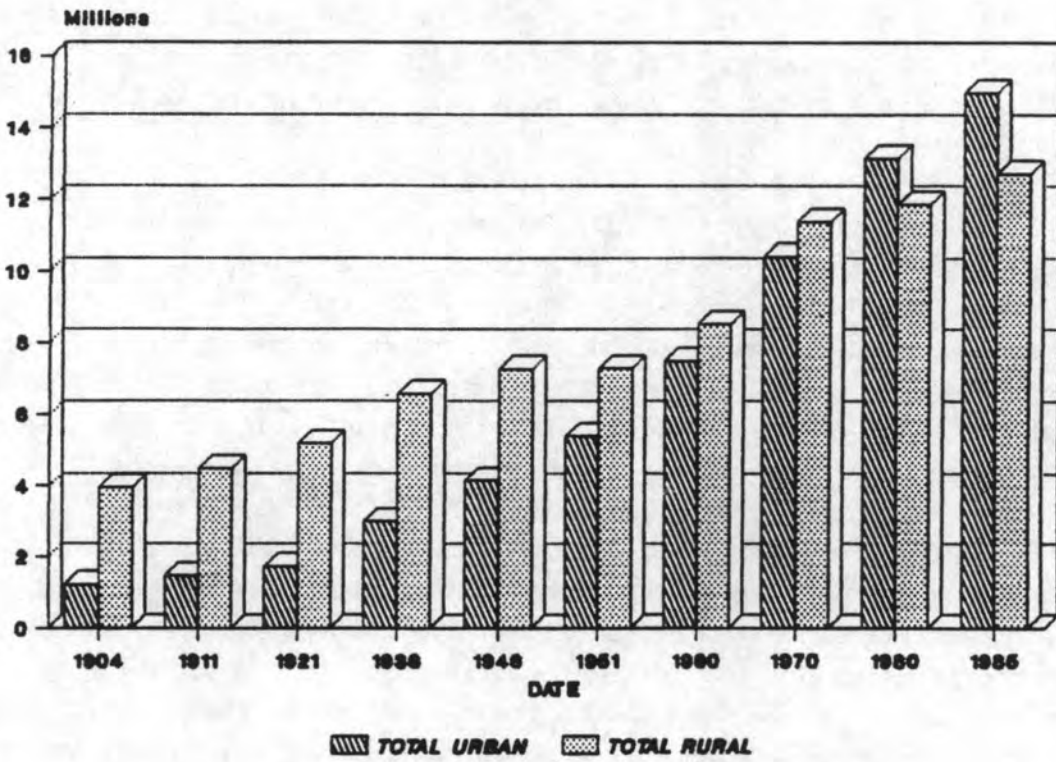
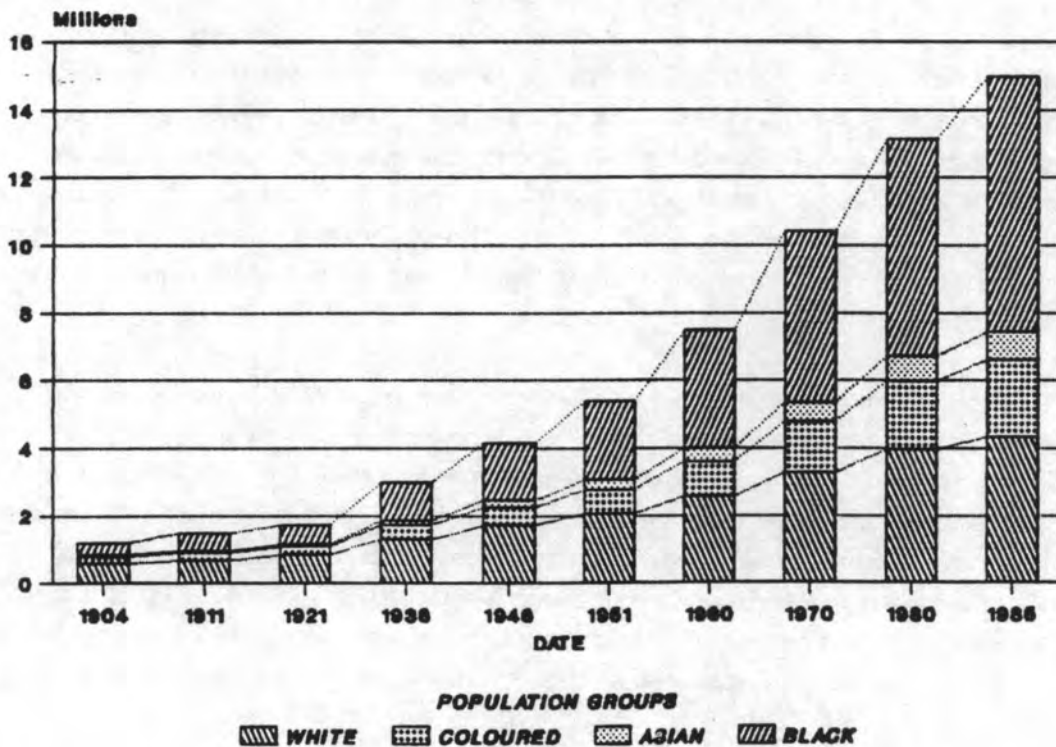


FIGURE 2.2 URBAN SUB-POPULATIONS OF SOUTH AFRICA: HISTORICAL DATA: 1904/1986



#### 2.1.6.2 Informal settlements

Squatter (or informal) settlements are being increasingly studied as it is estimated that about 7 million people live in these settlements in South African urban areas (Economist 1 October 1988:70 - quoting the Urban Foundation). That much of new urban growth is taken up in the informal settlements is illustrated by the fact that the Urban Foundation (Annual Review 1988) reports that two thousand new shacks are being built in Greater Durban every month.

In this area (Natal) A'Bear (1981) studied settlement growth in the Pietermaritzburg-Durban region at both macro and micro-levels. In the two communities studied in depth most of the household members (64% and 69%) were born in the settlements themselves and only a third of the population could be classified as in-migrants. The Inkatha Institute for South Africa (1986) notes that in 1983 of the some 3 million people living in the Durban functional region some 1,34 million lived in shack or squatter areas. By 1987 these figures were expected to be 3,6 and 1,73 million respectively. It was found that the people of the settlements were permanent (86% would not return to the rural areas), were an integral part of the region and had negligible services and facilities. Maasdorp and Pillay (1983) investigated in depth the socio-economic profiles of two informal settlements in the Durban area. In these communities it was found that some three quarters of the population had migrated for economic reasons, and that about half of the inducement was the 'push' factor in the form of rural conditions.

In an article in the Star (1 August 1988), dealing with a study by Dr Frankel of the University of the Witwatersrand, it was estimated that some 1,5 million squatters lived in the Pretoria-Witwatersrand-Vereeniging (PWV) area. Of these squatters the open veld shanty dwellers were the minority. Most squatters lived in the backyards of the formal townships in the PWV and the article stated *"It is not unusual to have 10 to 20 squatter households in a single backyard in the overcrowded areas of Katlehong, Tembisa and Thokoza on the East Rand"*. In one township (Tembisa) 94% of the squatters declared themselves to be permanent townspeople. Other features of the settlements reported in this article were that they housed the poor and very poor, were all overcrowded, had few services and that unemployment was a permanent condition for many but that there was also a vibrant informal economy.

In an early study in the Western Cape Weichel et al (1978) investigated some aspects of social and economic activity in Crossroads and Nyanga. A striking difference in the two communities in terms of community involvement was revealed. A sample of 200 interviews indicated a wide range of informal activity, with many small shack shops which they note *"sold only a few items such as sweets, paraffin or fruit and vegetables"* (p26). Ellis et al (1977) analysed the causes of the squatting phenomenon for both blacks and coloureds in the Western Cape where the housing shortage and overcrowding



were the major causes. Silk (1981) provided insights into the growth and demolition of the Modderdam settlement. This was a typical example of a major removal that had the net effect of none of the "removed" leaving the urban area. In this case, as in the destruction of Crossroads at a later date, there was a large intra-urban migration stream that resulted in higher than normal growth rates of other informal areas. Intra-urban migration of this type is often misinterpreted as rural-urban.

The Urban Foundation Western Cape (1987) provides the most detailed resume of urban informal settlements in South Africa. They point out in terms of the new controlled squatting mechanisms, *"It is hoped that once again, through controlling access to land and accomodation, albeit on a different basis, the urbanization process can be manipulated to conform to state policy"* (p2). The increase in the number and size of informal settlements is seen as inevitable as a result of the present economic climate, the inability of the homelands to be self-supporting, and the unaffordability of conventional housing. Some findings of the survey were that the settlements housed the very poor, services and facilities were inadequate, rent or a service charge was paid to landlords or leaders, and that informal income generating activities constituted a significant section of the economic base of the settlement.

The growth of Khayelitsha, a largely informal settlement on the outskirts of Cape Town, is a phenomenon that is poorly documented. Here the Surplus Peoples Project (1984) deal with the early stages of growth and resistance to forced removals to this area. The subsequent rapid growth of the area is due in part to rural-urban migration after the scrapping of influx control measures and the Coloured Labour Preference Act in the early 80s, in part to intra-urban migration after the destruction of Old Crossroads and in part to natural increase. This process has so far been documented only in the press.

## 2.2 ENERGY TRANSITION

### 2.2.1 Overview

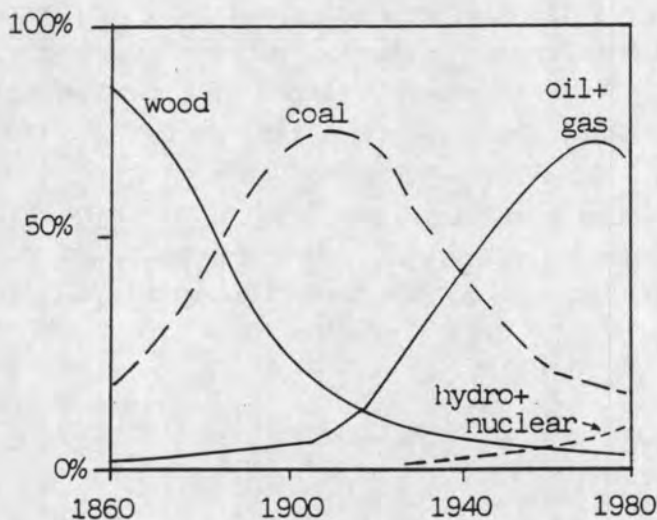
While the process of energy transition has been underway for centuries its description has only recently been added to the intellectual armoury of academics. Originally the preserve of historians (see for instance chapters 16, 17 and 22 of Derry & Williams, 1960) the energy transition process has become of concern to energy forecasters and development planners. The reasons for this concern are manifold. Energy is used in great quantities by the developed nations and the supply of energy to meet the growing demands of developing nations will tax the energy resource base of these countries and the world as a whole. Which energy resources are to be used by a particular country depends in part on the energy transition process through which the population is passing. It should be noted that the focus of this literature

survey is primarily on the domestic sector which can account for between 30% to 70% of total energy consumption in developing countries (Leach et al, 1986). It should also be noted that in these developing countries urban energy utilization has received little attention in literature compared with rural energy problems such as deforestation.

### 2.2.2 Energy Transition - International

Energy has had a changing role in human life as the economic base of societies has changed from agricultural to industrial (see Scientific American, September 1971 and Cook, 1976). When viewed at the time scale of centuries and at a national scale the energy transition process of the industrialized nations can be perceived as a series of consumption curves of different energy sources. When smoothed these curves take on the form of a series of bell-shaped replacement curves as energy sources are replaced by newer ones as indicated in figure 2.3 (source Eden et al, 1981). This figure illustrates the fact that several fuels are in use at any one time. Energy transition is the changing mix of these fuels over time.

FIGURE 2.3 MARKET SHARE OF DIFFERENT FUELS: UNITED STATES 1860 - 1980



There are wide disparities in energy use between developed and developing countries, 6,3 kWh/day per capita primary energy use in the former in 1980 versus 1,0 kWh/day per capita in the latter. Goldemberg et al (1987) note further that only 55% of the energy in developing countries was derived from commercial fuels. (Roberts (1987) notes the definitional problems of the terms traditional and commercial). However the future growth in the global demand for energy will come mainly from the less developed countries (Sassin, 1980). This is due in part to the levelling off of energy consumption in the developed countries, due to reasons of increasing energy efficiency and demography, and in part to the increase in energy consumption in the developing countries as the energy transition process occurs. This process



depends in part on the urbanization process and is described by Dunkerley et al (1981) as follows:- "Typically, as incomes rise, agriculture and industry become more mechanized, relative prices or availabilities of traditional fuels change, and urban populations grow rapidly. These changes tend to bring about a shift in energy consumption from traditional or 'noncommercial' fuels, such as wood and dung, to commercial fuels" (p1).

The link between energy and development, or stated differently, the influence of economic growth on the energy transition process, is investigated at the macro-level by Goldenberg et al (1987) who note, "The world has already witnessed a decoupling of energy and economic growth" and that "The coupling of energy use and economic growth can also be loosened in developing countries" (p7). The recipe for this decoupling is by increasing the efficiency of energy use by emphasizing the use of "high quality energy carriers" such as gas and electricity. Energy is however still hugely important to Third World economies, viz., "On average, electricity companies in poor countries eat up 20% of government development budgets and their borrowing can amount to some 40% of a country's foreign debt" (Economist 7 May 1988). In the case of electricity "At present every 1% increase in a poor country's GDP pushes up its electricity consumption by 1.4%" (Economist, *ibid*).

A study by Cecelski et al (1979) focusses on energy in poor households in the Third World as household energy in the developing countries accounts for about 50% of total energy consumption. Some broad conclusions are that energy is used with great inefficiency in many parts of the developing world and that cultural and institutional factors are important in changing energy technologies such as new appliances. A tentative conclusion is that, "energy consumption measured in quantity terms rises by less than the rise in income - at lower income levels at least" (p4). The data analysed indicates that after a certain threshold income, higher than that of the urban and rural poor, there may be a sharp increase in household consumption as access to new fuels is achieved. With regard to policies, two approaches to equalising the access of the poor to energy are identified. Firstly credit policies which allow expenditures to be spread over time, and secondly technical 'fixes' or price subsidies which lower the price of energy.

In Dunkerley et al (1981) patterns of energy consumption and supply in 12 countries, 8 of which were developing, were investigated. The vital role of biomass fuels in the poorest countries, where it could account for up to three quarters of total energy used, and the "fuelwood crisis" whereby the "price" in terms of increased times of collection, are noted. The difficulty of defining the "household" sector is that, "Household activities merge with a variety of agricultural, commercial and workshop activities" (p51). Energy data for developing countries lump these activities together thereby making the household sector a 'residual' sector. With reference to the choice of fuels "...household sector fuel choices are

influenced by overall costs of fuel, capital (stoves), labor (time), rather than fuel costs alone" (p56). The energy transition process is broadly analysed for a few countries and it is concluded that convenience and the demand for services such as lighting and appliances play a role in the shift from non-commercial to commercial fuels. In addition "fuels such as kerosene may play a transitional role between noncommercial fuels and electricity". In a footnote varying income elasticities for kerosene of between 0,78 and 1,59 and even some of zero and negative values are reported and the authors feel "These results can all be accommodated within the hypothesis that kerosene is a transitional fuel".

Energy transition in the rural areas has been much slower than that in urban areas and biomass is still extensively used in these areas. Massive deforestation has resulted in some countries with the consequential increase in the time taken to collect fuel, over six hours per trip in the case of Nepal (New Scientist 10 Sept 1987:59). The rural energy transition process is investigated in detail by different authors in eight developing countries and collated in Wionczek et al (1981). Foley and van Buren (1981) note the contrast in the subsistence economy between the high and inefficient consumption of energy for domestic uses and the extremely low consumption for productive purposes. As wood is the principal source of fuel for three quarters of the developing world the constraints on subsistence energy use relate largely to the availability and depletion of wood supplies. Attention is drawn to the fact that subsistence societies are almost impervious to change as they are largely a cashless society and all fuels apart from wood require some cash outlay. It is noted "The commercialisation of fuel cannot be entirely separated from the general transition from a subsistence to a cash economy" (p5). Of all the cases reported only in Korea has a series of rural energy transitions been planned and executed. Kim (1981), analysing this country, notes the rapid urbanization, from 44% in 1961 to 79% in 1979. At the beginning of this period Korea's main energy source was fuelwood (57%) and at the end oil (63%) and coal (23%). There is a sharp difference between the rural use of fuels - 82% firewood, and the urban areas - 82% coal and 2% wood. This is surprising as by 1979, 98% of villages had electricity. The reforestation schemes undertaken have allowed the absolute consumption of firewood to remain fairly constant. The government actively encouraged the transition from fuelwood to coal even in the urban domestic sector. It is noted that the "second" energy transition, from coal to oil took place as a result of a shortage of coal due to the rapid increase in demand caused by urbanization. The government response was to restrict coal supplies to the non-residential sectors. In Senegal, reported by Sene (1981), a substitution programme of butane gas for wood and charcoal failed to reduce the amount of charcoal used in urban areas as a result of the high price of gas. Also, "...this programme had no effect whatsoever on the rural subsistence sector energy balance" (p139). The role of education in use of scarcer woodfuels and an open mindedness to new fuels is stressed.

Mexico has important parallels with South Africa in terms of its GNP,

population size, growth, and the prevalence of a modern economy alongside a large rural subsistence economy. Guzman (1981), reporting on Mexico, describes in detail the large subsistence farming sector of that nation which reveals, *"...the limited capacity of subsistence producers to break out of the apparent equilibrium of the peasant economy and accumulate a surplus, however small"*. While Mexico is a major oil producer the share of the agricultural sector in national consumption fell and indeed the demand for oil products in this sector fell in absolute terms. On subsistence farms non-commercial fuels still accounted for 84% of delivered energy and human and animal energy are still predominant in the production of subsistence crops. In the lowest income groups cooking still takes place over an open fire. Energy policy measures in the rural areas of Mexico have been electrification and the subsidisation of paraffin for domestic use. However. *"...even after several decades of self-sufficiency in oil, with abundant supplies and low prices, other forms of energy are still the predominant fuels among the peasantry"* (p62). Guzman criticizes the fact that these other forms have been ignored in the formation of an energy strategy.

At the macro-level China may also represent a model of interest to South Africa. In that country there is heavy reliance on coal which accounts for approximately half of the total primary energy consumption while biomass is second at about 25% of primary consumption (World Bank, 1985).

Stassen and van Swaaj (1981), on the question of rural energy policy, feel that to counteract the outstripping of woodfuel supply by demand and the increasing reliance in these areas on cheap commercial fuels, *"... the best approach is to promote rural self-sufficiency in energy by increasing energy production, and by encouraging the substitution and more effective use of indigenous and, preferably, renewable resources"* (p21).

In a later study Leach et al (1986) investigated energy and economic structures in a comparison of 13 industrial and developing countries. They note the special role that biomass plays in middle and low-income countries and note, *"by focussing almost exclusively on fossil fuels and hydropower schemes, planners in these countries may get a seriously distorted view of energy growth prospects and planning priorities"* (p4). They also note the international concern with energy use in the household sector of developing countries where there is a heavy dependency on biomass, and at the rapid growth of household use of fossil fuels - often at 8% to 12% per annum; *"Urbanization, improved supply systems and rising incomes add to the basic attraction of these convenient and clean energy sources..."* (p141). These authors note that a characteristic of the household sector is its enormous variability. In this study it was found that the dependence on biomass fell very sharply with increased income over time for most of the developing countries. It was also found that there were striking differences in terms of household energy sources between the urban and rural areas of the countries studied with energy use and biomass consumption being much lower in the former. In addition, in the urban areas *"commercial*



*fuels are used at relatively low income levels and show a very rapid increase at higher incomes" (p152). The effect of household size was pivotal in that it was found to largely explain the growth of household energy consumption with household income. A feature that both developing and developed countries shared was that household energy consumption grows much more slowly than income. This has important social implications as it means that the poor spend proportionately very much more of their family budget on energy than do higher income families. An important conclusion is that, "This view that a major transition in household energy use accompanies rising incomes, urbanization and other aspects of development, stands in almost complete contrast to projections of global firewood consumption.." (p159). However, they add that the determinants of energy consumption in households are not well understood.*

Leach (1987) in a recent study of energy transitions in the household sector in South Asia summarises the process as follows; *"Families attempt to move up the ladder of fuel preferences for cooking and heating towards greater convenience, cleanliness, time saving and 'modernity'" (p1). He notes that the process is "driven by income, but also by scarcity of biofuels" (p10) and is strongly affected by fuel prices, the cost of appliances and the availability of fuel. Since the transitional fuels are not full substitutes of the biofuels they replace and because of irregular fuel and power supplies the multiple use of fuels is common. Leach's study is based on both cross-sectional and time series data for India, Pakistan and Sri Lanka. In the first two countries, where premium fuels are more easily available, biofuel shares fall steeply with income. He notes that the falling real prices of gas and electricity and the fact that kerosene has always been cheaper than wood on a useful heat basis has encouraged the urban energy transition.*

Pearson (1987) considers medium and long term energy transitions in Asia. He notes *"...in order to understand and forecast LDC energy demand, it is important to appreciate what kind of transitions (if any) a country is making and at what stages it is in those transitions, since there is both long-term substitution and a degree of short-term switching between traditional and commercial fuels" p(3). Both macro and micro factors influence energy transitions but at the latter level the processes of energy decision-making within households are not well understood. Pearson states that household energy demand is a function of fuel price, prices of substitutes, tastes, household socio-economic and physical characteristics, dwelling characteristics, season and temperature, characteristics of the fuels and characteristics of the appliances. Pearson investigates the energy transition process at the macro-level, using data from the Asian Development Bank and World Bank, and by regression analysis confirms the expected relationships between energy consumption and broad development indicators. These are that commercial energy as proportion of total energy consumption is related to development indicators such as the percentage living in urban areas, industrialisation, radio ownership, car ownership etc.*

### 2.2.3 Energy Transition - Africa

Soussan (1987) notes that the decreasing share of biofuels in some LDC's "often reflects increased consumption of commercial fuels in other sectors of the economy more than a move away from the use of biomass fuels in households" (p4.1). Unlike Pearson above he feels that "The pace of this transition, is so slow as to appear almost imperceptible" (p4.2). The main factors that precipitate energy transitions are firstly economic development - economic growth and income distribution, and secondly urbanization - "This is partly a question of supply, free biomass fuels are rarely available to the urban population, and partly one of prosperity, in most Third World countries urban incomes are higher" (p4.3). A third factor is the increasing scarcity of biomass fuel supply and the fall in real costs of commercial fuels. Soussan's data is based on surveys in Kenya and Grenada. In the former country he notes that the effect of income on energy consumption is linear, the use of more than one fuel is the norm and that there is considerable variation in the quantity of each fuel used by households within each income group. In addition energy transition in Kenya was an urban phenomenon. The author concludes "The crucial feature of these changes is that they occur over time within individual households, and during the transition these households will be extremely flexible in combining different quantities of different fuels in response to fuel costs and availability, income availability and other household needs" (p4.5). It is suggested that past changes in fuel use are not irreversible.

Elkan (1987) analyses alternatives to fuelwood in African towns and notes that on this continent the urban poor rely almost exclusively on fuelwood. The major reason is that fuelwood continues to be cheaper than the alternatives, albeit as a result of its non-commercial nature at present (and the artificial depressing of urban fuelwood prices by some African governments), and in spite of the subsidisation of kerosene. The author states that in the short to medium term paraffin (kerosene) is the only alternative to fuelwood or charcoal. However, "The principal reason why kerosene has made no great headway is that its use requires a cooker that is very much more expensive than the three stones needed to make an open fire .." (p3.7). For lighting however, where home-made appliances are possible kerosene is now widely used. Elkan dismisses the establishment of fuelwood plantations, noting that while indigenous wood is available and used as a "free" good, commercial wood will not be competitive. He cautions that while a fuelwood solution to the fuelwood problem may not be feasible the switch to conventional fuels will depend on stable oil prices, a marked reduction in the cost of conventional fuel appliances and the rise of the incomes of the poor to the level of the present middle class. Thus, "The 'conventional fuel' solution to the fuelwood problem may therefore be no more practicable than the fuelwood solution it is supposed to replace" (p3.16).

Hughes-Cromwick (1985) describes the results of an urban household energy survey conducted in Nairobi, Kenya in 1981. She points out that two independent phenomena, the oil prices changes since 1973 and the depletion of non-commercial fuels, have impinged on the availability of energy in Kenya. Although woodfuels account for 68% of Kenya's energy demand only 7% of Nairobi use this fuel - 65% use charcoal and 78% electricity. She notes that urbanization has influenced energy utilization as rural migrants who used wood and charcoal now use gas, paraffin and electricity. The survey revealed a dichotomy between the reasons for primary fuel usage; price and income in the case of lower income groups and convenience and availability in the case of higher income groups. This accords with choice of fuel, charcoal and paraffin at the low end of the income scale and gas and paraffin at the upper end. Wood is primarily used for heating while charcoal and gas are primarily used for cooking. Electricity on the other hand is used for a variety of purposes. It is noted that the average basic energy demand for cooking with gas is significantly (about 50%) greater than with charcoal. Also "*The average basic energy demand for electricity multiple end uses is larger than comparable end-use combinations of other fuels*" (p273). In terms of fuel consumption a pattern of increased use of charcoal and then a reduction as gas and electricity are substituted was found. Paraffin for cooking on the other hand declined at higher income levels. In terms of energy consumption a significant finding was that mean energy consumption increased not only as income increased but as the usage of a fuel for multiple activities increased. Regression analyses yielded the findings that electricity energy demand was income elastic (a 1% increase in income resulted in a 1.58% increase in energy demand) but that household size explains a large portion of the variation in electricity energy consumption. On the other hand charcoal energy had negative income elasticity (-0.23) whereby it declined as incomes rose and also household size seems to be an important determinant of charcoal energy demand. In the case of paraffin energy consumption household size and the number of paraffin appliances were more important determinants than income and although positive, the income elasticity was small (a 1% rise in income leads to a 0.25% increase in paraffin energy demand). In the case of gas energy consumption only price was a determinant and was thus income inelastic. The author concludes that the results "must be integrated with other social and economic factors for effective policy making" (p278).

#### 2.2.4 Energy Transition - South Africa

##### 2.2.4.1 Rural areas

Early attention to the importance of biomass as an energy resource, and to the diminishing fuelwood resources in South Africa was drawn by Bond (1977). Prior to this fuelwood had been studied as one facet of a set of socio-economic conditions under investigation by Clarke and Ngobese (1975). Gandar (1979) summarised the lack of attention given to fuelwood as an energy source



in South Africa, noting that the Department of Planning and Environment in studies of energy trends and consumption in 1975 and 1978 did not consider fuelwood.

The field of interest narrowed to focus solely on rural domestic energy in subsistence communities with the work of Best (1979). Best selected three villages in Lesotho, Transkei and Kwazulu which were visited both in summer and winter and the consumption of fuel of various types measured with some rigour. The major fuels used in these villages were wood, dung and paraffin, and the minor fuels coal, candles, crop residues and other combustible materials. It was found that there was a large variation in the energy consumption of households on different days and also a discernible seasonal variation. The average annual per capita energy consumption of all the villages was 13,96 GJ, with a wide variation between Transkei (7,69 GJ) and Kwazulu (23,86 GJ). Best concluded that the availability of firewood in the vegetation around each village had a major influence on the consumption of domestic energy. It was noted that in some cases women had to walk for 3 hours to collect wood. Gandar (1979) estimated the total fuelwood consumption in the homelands to be 5,4 million tons per annum, based on the energy utilisation estimates of Best (1978).

Liengme (1983) studied the use of wood for both fuel and building in a village in Gazankulu and found that the average daily family consumption of wood was 14.9 kilograms, with wide variations in this mass, influenced in part by family size. Gandar (1983) noted that rural fuelwood was seen as a free good, a right and a necessity and estimated it contributed between 5% and 10% of national primary energy consumption. He concluded that wood would be the dominant fuel (on a per capita basis in rural areas) for the foreseeable future as it was *"...convenient, relatively cheap, does not require fancy appliances and is renewable"*.

Moller (1985) in a study with a large sample (5500), of perceptions of basic needs by blacks, that covered both rural and urban areas, states, *"over four-fifths of rural and white farm blacks stated they use wood for cooking or heating their homes"* (p14). In the townships the ratio for cooking by wood was 38% and heating 26%. However 45% of the rural firewood was purchased and 10% had to walk more than 30 minutes to collect firewood. Some 30% of the rural sample used dung, *"Most likely this is an indication that other more suitable fuel types are not available."*

Eberhard (1986) studied energy consumption in South Africa from the full range of energy sources. The rural component of this study consisted of six villages in three bioclimatic zones. It was found that all families in these villages used fuelwood and the number of families using paraffin ranged from 85% to 100%. Eberhard notes, *"Wood is clearly the dominant fuel, although it is noticeable that other fuels are extensively relied upon - particularly paraffin and also agricultural wastes such as dung, mielie cobs and stalks"* (p28). Eberhard also found signs of woodfuel depletion,

such as long times required for collection and extensive commercialization of woodfuel. The total annual household fuel expenditure ranged from R55 to R271 with expenditure on wood ranging from 30% to 63%, and expenditure on paraffin from 22% to 56%, of the total expenditure on fuels.

Eberhard and Dickson (1987) studied two broad areas in Bophuthatswana with the focus on fuelwood. In the rural areas of this study 90% of the families in the survey relied on fuelwood, of which some 45% was purchased. The average per capita consumption of fuelwood is 404 kg which it is observed *"...compared with studies in other areas of South Africa, is very low and indicates a serious fuelwood shortage"* (p1). About half of the average household fuel expenditure is on paraffin (162 litres/annum per family).

Tobich and Dingley (1988) surveyed 10 rural villages and five small towns in the Ciskei in a study that focussed on the potential electrification of these areas. The sample size for each town or village was small and no quantitative data on energy consumption is provided. It was found that paraffin was the most commonly used fuel, with 99% of rural households and 98% of urban households using it, while fuelwood was used by 86% and 57,5% respectively. Dung is a major fuel in rural areas. Coal and gas are minor fuels in both areas. Paraffin accounted for about 50% of the total fuel cost in the rural area and 44% in urban areas.

The best estimate so far regarding homeland fuelwood demand and supply is by Aron, Eberhard and Gandar (1989). They note, *"Fuelwood consumption varies greatly between rural, peri-urban and urban settlements and the calculation of fuelwood demand is dependent on assumptions regarding the split of population between these settlement categories"* (p8). The demographic data of Graaff (1986) is combined with existing consumption data from various sources and consumption figures of 5,45 million tons/year in 1980, and 8,31 million tons/year in 2000 calculated. In terms of supply of fuelwood six sources are identified with the greatest contribution from scrubland and woodland. The annual sustainable above-ground yield of woody biomass from natural shrubland and woodlands in the homelands was estimated to be 11,6 million tons per annum. Of this 5,8 million tons could be regarded as sustainable usable fuelwood. Based on these figures the authors calculate fuelwood deficits which are already 4 million tons per annum by 2000 and complete depletion in 40 years.

#### 2.2.4.2 Urban areas

In a study of energy and the urban poor Eberhard (1984) notes the large disparities in domestic energy consumption between the white and black population groups. The percentage of income spent on domestic energy is found to decline rapidly with increasing income in both Crossroads and the relatively more affluent coloured areas surveyed. In the case of Crossroads paraffin was the most important fuel, followed by coal and then wood.



The urban component of Eberhard (1986) is the first major study of energy use in informal settlements. Five peri-urban areas, including Crossroads in the Western Cape, were surveyed by means of structured questionnaires. In these informal settlements fuelwood was still a major fuel source although the percentage of users who bought wood rather than collected it themselves was high. It was found that 38% of the Crossroads residents interviewed used wood, while 100% used paraffin, the mean annual per capita consumption thereof being 96 litres. Coal consumption in this informal settlement was relatively high at 217 kg per capita per annum, while the usage of gas was low at a mean of 1.7 kg per capita per annum. The high incidence of wood use should be seen in the context of the large available resource in the form of the Port Jackson shrubland that covers large areas of the Cape flats.

Eberhard (1986) found that per capita energy consumption in the peri-urban areas was not higher than the rural areas, in spite of higher disposable incomes and speculated that this could be explained by the higher efficiency of fuels used in the former areas. However his results indicate that of the peri-urban areas the highest proportion of household income spent on energy is in Crossroads, which is within the Western Cape metropolitan area. In a further survey of Vulindlela, one of the villages in Eberhard's study, Scholtz and Dingley (1988) give a revised mean monthly fuel expenditure of about R64 compared to the figure of R29,33 from the Eberhard survey undertaken in 1984/5.

In the peri-urban areas of Bophuthatswana studied by Eberhard and Dickson (1987), 75% of the households used fuelwood, with an average per capita consumption of 134 kg per annum. In these areas 96% of the families sampled used paraffin and the consumption was 224 litre/annum per family which accounted for 50% of the mean monthly household expenditure on fuel. Eberhard, Dickson and Pouris (1989), in an article based on the survey reported in Eberhard and Dickson (1987), deal for the first time with energy transition in South Africa. They state, *"Urbanization is one of the main factors affecting household energy transition in developing countries but its effects can only be verified empirically"* (p424). They continue, *"The classic pattern of substitution of dung and fuelwood for coal and paraffin appears to be the dominant paradigm"* (p424). They conclude *"Economic development, the degree of urbanization and the relative availability of biomass and commercial fuels appear to be the main determinants precipitating energy transition in Bophuthatswana"* (p425).

Read Consultants (1988) investigated the usage of energy in Botshabelo and Mangaung in the Orange Free State. The former is a resettlement camp with an estimated population of between three and four hundred thousand and the latter a black town with a population of about 100 000. Botshabelo is not electrified while a proportion of Mangaung is. In the former area paraffin accounted for 38% of total energy costs in summer but fell to 25% in winter when wood accounted for 20% and coal 30% of total energy costs. In Mangaung paraffin was still the primary fuel in summer (28%) followed by electricity

(25%), but in winter coal (27%) was followed by electricity and paraffin, both of which contributed 20% to the total energy cost. The gap in expenditure between the electrified and non-electrified families is insignificant, and both groups use multiple fuels in both summer and winter. While no quantitative data on energy consumption was collected Eberhard (pers comm) calculates that those with electricity are using more energy, particularly useful energy and the cost of this useful energy is much lower than that in the non-electrified group.

Basson (1987) summarized some of the available data for rural and urban domestic energy. In this paper the influence of "accelerated" urbanization on the use and supply of energy is briefly considered. He notes *"One of the most serious effects is in terms of the environment, especially in South Africa, as a result of cheap coal and the effects of its incorrect combustion"* (p14).

### 2.3 CONCLUSIONS

From the literature it appears that a non-Eurocentric paradigm may provide deeper insights into the process of urbanization in South Africa. If an historical viewpoint is taken and the process seen as "dependent urbanization" the pattern of continuous rural-urban migration from the impoverished rural areas is the inevitable result of the enduring cultural clash and dominance of the white population. African urbanization is however a special case of Third World urbanization. The unique system of circular migration, the high rates of population growth, the low levels of urbanization and the enduring poverty result in a process of urbanization that depends on the capacity of the informal sector to absorb the new urbanites. This "backwash urbanization" (Mabogunge, 1986) paradigm suggests that urbanization may not result in economic development - the opposite in fact. This inverse correlation of high urbanization rates and low economic growth rates is corroborated by Potter (1985).

Applying the "backwash urbanization" paradigm to South Africa the high rate of urbanization could be construed as a "backwash" effect of inappropriate rural policies, based on urban exclusion rather than rural development. The growth of the informal sector has indeed been high, although measuring it is difficult (but see van der Berg, 1989 - the residual labour force growth from 1974 to 1985 was from 24% to 38% of the total labour force). The level of poverty is seen by Wilson & Ramphela (1989) to be rising (although this view is challenged by others, see Financial Mail 18 August 1989). This paradigm is in direct contradiction to the "positive urbanization strategy" which is predicated on a positive relationship between urbanization and economic growth. Adopting this paradigm would have wide effects on the growth scenarios of the future of South African cities and on the demand for energy in these cities.

Focussing more narrowly on informal settlements it appears that these will be the dominant element of urban growth in the future. The permanency of these settlements is revealed in the few studies in these areas in South Africa, as is the major role played by the informal sector. At present migration appears to account for only one third of the growth rates of these areas. Intra-urban migration however results in high growth rates in certain areas. The spatial aspects of the demand for energy will be largely dictated by the patterns of growth of these settlements. In terms of electrification the Brazilian example should be noted where some 70% of the informal settlements are electrified.

The literature survey indicates that the domestic energy transition process has only recently become the subject of investigation. The importance of the process to developing countries is due to the share the domestic sector has of total commercial energy demand (up to three quarters in the poorer countries), the rapid increase in fossil fuel usage and the high income elasticity of electricity. In spite of this perceived transition, macro-level studies of several countries reveal the intransigence of the subsistence sector to change in fuels used. This is particularly a problem in Sub-Saharan Africa which contains the countries with the highest proportions of traditional fuel use.

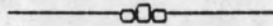
At the macro-level the link between economic development and the energy transition process is reasonably clear. Certain broad indicators of development, notably levels of industrialisation and urbanization, are well correlated with energy consumption. The choice of fuels is however at the core of understanding the energy transition process. Some understanding of the number of factors that influence choice of fuels is gleaned from the micro-level studies. Household economic characteristics - income, expenditure and wealth; household social characteristics - age/sex composition, sex of household head, labour divisions; built environment factors - size and type of dwelling; climatic factors, characteristics of the fuels - convenience, safety, odour and the stock and characteristics of appliances are one set of factors. Another set of factors relates to the prices of fuels. Here it is unclear whether actual prices, prices per useful energy unit or perceived relative prices are dominant in the price signalling mechanism. The number of factors accounts for the large variability of energy consumption among households reported in the literature.

In Africa, at the micro-level, there are indications that an energy transition process is underway. This process is largely confined to the cities where the lack of access to traditional fuels is as significant factor in the process and is thus linked to the urbanization process. The transition is away from traditional fuels to paraffin, gas and electricity. In South Africa traditional fuels still supply a large proportion of the rural household energy budget. The degree of commercialization of woodfuel is however high - indicative of fuelwood shortages. In addition there is a high penetration of paraffin in the rural areas. In the peri-urban areas of South



Africa the incidence of woodfuel usage is still high but in the urban areas it is low. In these areas the dominant fuels are coal and paraffin.

The literature survey reveals an underlying economic determinism in the approach to the analysis of the energy transition process. At the macro-level fuel price and income levels are the two factors used almost universally. At the micro-level additional factors are often introduced but the model is still economic. The spatial dimensions for the demand for energy are rarely mentioned, or subsumed under the general heading of "urbanization". The underlying demographic variables that influence energy demand are often dealt with in the same way.



## CHAPTER 3

### THEORETICAL FRAMEWORK, RESEARCH METHODOLOGY AND SURVEYS

#### 3.1 THEORETICAL FRAMEWORK

A framework is required within which data collected may be organised and interpreted. Consumer theory offers one such theoretical framework within which energy transition may be explained. Consumer theory has two components - the economic and the behavioural. Both components of consumer theory attempt to explain acts of choice, of a consumer or household, at a given time or over a period of time.

The economic component is well developed (see Deaton & Meullbauer, 1980). The theory postulates that, inter alia, consumer demand is moulded by budget constraints, which are often assumed to be linear. As the total expenditure of a consumer (or household) increases the relative expenditure on different categories change and may be plotted as Engel curves. The slope of these curves represent income elasticities. These curves can be used to classify goods into luxuries, necessities and other categories of goods. Within the budgetary constraint the choice problem is approached as the maximization of utility. On a practical level choice is generally predicted along with substitution rates in the form of own price and cross price elasticities.

The behavioural component of consumer theory has a multi-disciplinary basis (see Britt, 1979) but is dominated by psychology and anthropology. Market research falls into the ambit of this component. The view taken is wide - that there are cultural, individual and group influences on consumers - and that these influences outweigh the purely economic aspects of the behaviour of consumers.

That fuels do not behave as purely economic commodities has been recognised for some time. Regarding the fuel and light category an ILO (1932) report states *"Though the quantities of fuel and light consumed by typical families vary with income in every given country, the indications are that this is due rather to the size of the dwelling and the size of the family than directly to the increase in income."* Fuels are not only influenced by environmental considerations, such as climate and dwelling characteristics, economic considerations such as income and price, and behavioural considerations such as tastes and attitudes but also societal context.

Societies are however not static. The Engel curves of an average household change over time. In the case of Britain, illustrated in figure 3.1, there

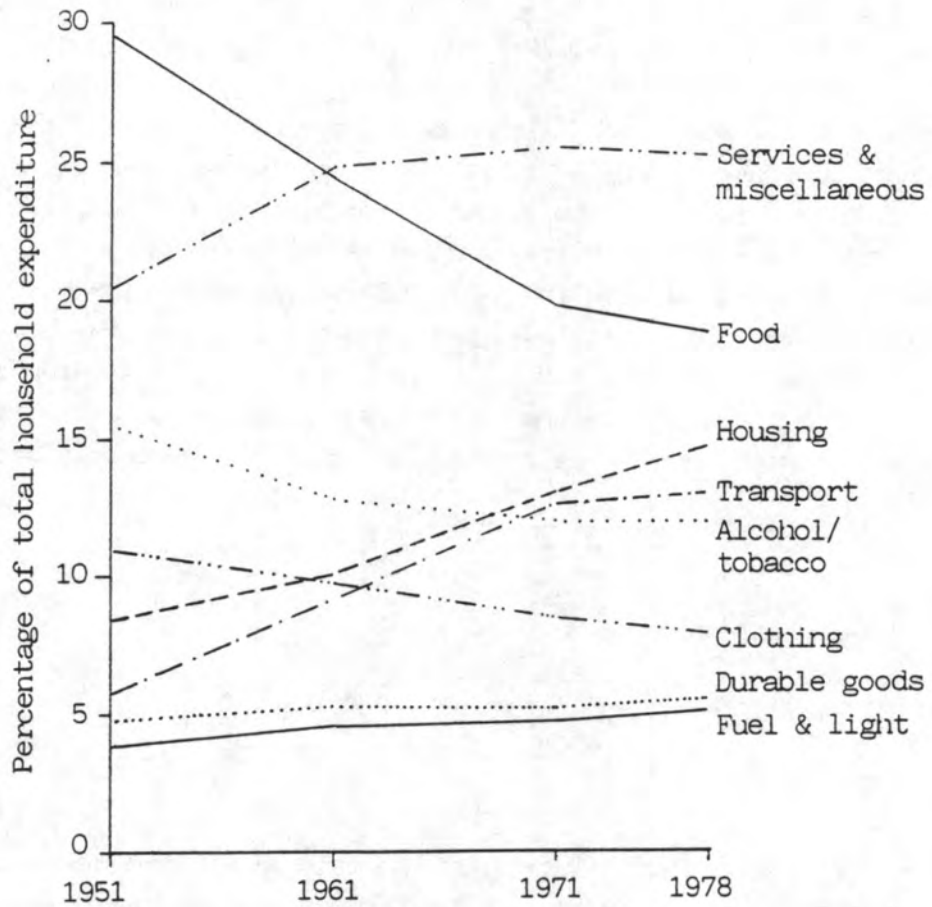
have been large changes - particularly in the food, services, housing and transport categories. These changes indicate increasing expenditure on luxury items and hence an increase in average household wealth, and equally a major change in tastes, fashions and attitudes.

The theory described above does not however apply fully to Third World countries. Here household wealth may be static, or even decline over time. More important, household wealth is redefined in the transition from rural subsistence to urban commerce by the process of urbanization. New categories, such as services, vital in an urban economy, are added. An additional Third World phenomenon, noted in South Africa by Loubser (1988), is the surpassing of income by expenditure at lower income levels. This is due to the system of long term loans, a form of "negative saving", that are not considered income and rarely reported. The implications of this are that the average slope of the expenditure curve, and hence income elasticities, is negative. Figure 3.2 indicates this phenomena.

When dealing with the Third World where inequality is ubiquitous, the characteristics of the sub-population under consideration may differ radically from the majority, or minority as the case may be. These differences thus need to be scrutinized. Inequality also results in limits to choice which are as influential in determining choices as preferences themselves.

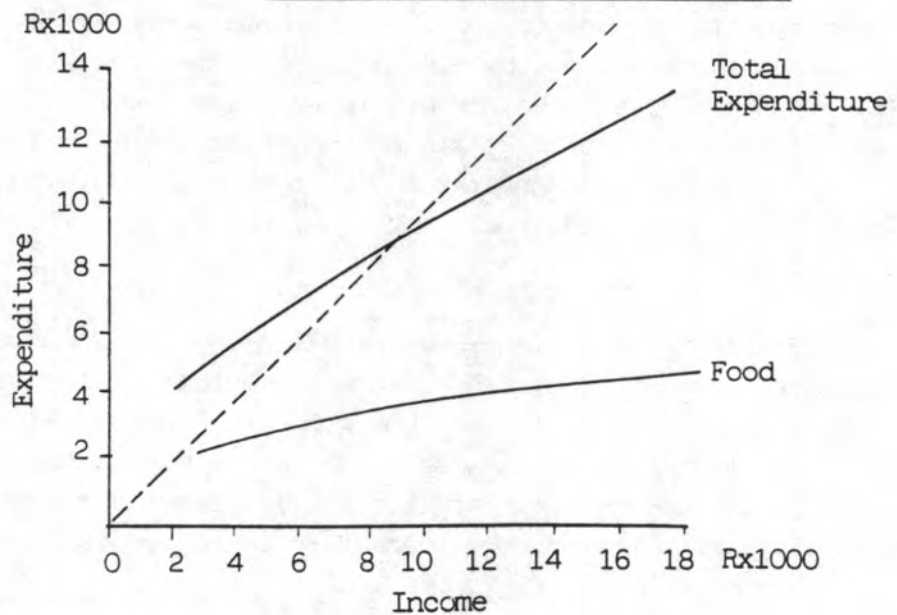
It thus appears that the economic component of consumer theory has lower applicability outside formal economic systems. The behavioral component may offer more insight in the informal sector and areas at present. In this study elements of both components are adopted. The unit of investigation is the household and energy transition is viewed within the context of the household budget - extended, poverty stricken and semi-subsistence though that household may be.

FIGURE 3.1 CHANGES IN THE STRUCTURE OF HOUSEHOLD EXPENDITURE IN BRITAIN. 1951-78



Source: Daniels (1982)

FIGURE 3.2 RELATIONSHIP OF INCOME AND TOTAL EXPENDITURE (BLACK HOUSEHOLDS) SA.



Source: Loubser (1988)



### 3.2 ANALYSING ENERGY TRANSITION

To analyse the domestic energy transition process three fundamental questions have to be answered. Firstly which fuels will be used. Secondly what quantity of these fuels will be used. Thirdly, at what rate will fuels be substituted.

Cross-sectional data both at the macro and micro scale, adequately answers the first two questions. The third question however introduces the element of time which is effectively only dealt with by time-series data. The short span over which data for this dissertation was collected ruled out obtaining time-series data. As a result, the rate of fuel substitution has to be inferred from comparisons of micro-level cross-sectional data and correlations with time related socio-economic variables. In addition this rate may be obtained by broadening the scope to include the use of macro data to allow comparisons between countries, and by using time-series market research data within South Africa.

### 3.3 RESEARCH METHODOLOGY

#### 3.3.1 Introduction

##### 3.3.1.1 The Macro-Scale.

The research methodologies utilised in this study have been dictated by the hypotheses that are to be tested. As the process of energy transition is most clearly discernible over the longer term and at the national scale a brief macro-scale investigation was judged necessary. Existing data from various energy surveys, market research surveys and data on price increases for various fuels have been drawn together to form a small and somewhat eclectic macro data set.

##### 3.3.1.2 The Micro-Scale.

A project entitled "Energy use in low income dwellings in the winter rainfall area" was commenced (not by the author) under the auspices of the Energy Research Institute at the University of Cape Town in 1987 and 1988. This project formed the initial basis of the micro scale investigation in that the data from the survey undertaken for this project (hereinafter termed the initial survey) were adopted, but, for reasons set out below, could not be used in toto.

As a result of the abovementioned adoption of data the questionnaire used in the initial survey dictated a core of questions to be followed in the subsequent surveys to allow for backchecking and validation of the initial data. This meant that the research method of structured surveys was adopted partially by default. In addition this questionnaire had the implicit hypothesis that the energy transition process is determined solely by



economics. This view was altered to consider social and behavioural factors in the process as set out below. In addition the scope of the study was broadened to include the Transvaal.

### 3.3.2 Formulation of Hypotheses

The broad hypotheses tested in this study are as follows:-

- 1) There is a process of change of fuel usage by the black population that can be discerned over time and space and this energy transition process can be partially explained in terms of a variety of socio-economic variables.
- 2) The energy transition process is a function of modernisation and not simply the geographical aspect of urbanization. i.e. The process is not a function of population movement alone.
- 3) The energy transition process differs between rural area, town and metropolitan area.
- 4) The energy transition process is a function of choice within a given budgetary and behavioural framework.
- 5) The role of economic factors in the process gives way to social and behavioural factors as incomes increase.
- 6) The commercialization of energy resources and the efficacy of the distribution systems of these resources play a fundamental role in determining the nature of the transition process.

### 3.3.3 Research Methodology

#### 3.3.3.1 Choice of method

At the macro-scale the research method was collection and collation of existing data. At this scale statistics on energy supply are more readily available than statistics on energy demand. Detailed information on energy use and distribution patterns are generally not available.

At the micro-scale the research method adopted in this study was the study of specific areas by means of structured interviews. A number of different questionnaires were used for different purposes as set out below. Groen and Huizenga (1987) note that most of the 600 rural energy studies that they examined used questionnaires. Participant observation, direct measurement, key informants and group interviews are considered as alternative methods in some cases.

#### 3.3.3.2 Limitations of the method.

One limitation of questionnaire surveys is the difficulty in deciding on a sampling frame in the absence of accurate figures on the total population under investigation. This is particularly acute in the urban areas of South

Africa where underenumeration and lack of data in inter-census years results in huge disparities between "official" and "unofficial" population estimates. As a result the level of confidence in data is not accurately ascertainable. Additional limitations of questionnaires are the unsuitability for examining complex issues, difficulties in respondents understanding the question after translation by the interviewer, and the problem of dealing with the similarity of response. In spite of these limitations the technique is still the most cost effective way of obtaining information for small scale investigations.

### 3.4 THE INITIAL SURVEY

#### 3.4.1 Objectives

In a progress report Pouris (unpublished) stated "The objective of the report is to identify the quantity, uses and type of energy used in the second (sic) world houses in the winter rainfall area of South Africa and estimate the effect income has on energy consumption."

The main questions set out by Pouris were:

- 1) What are the determinants of choice of energy used in urban dwellings ?
- 2) How does income effect energy usage in urban dwellings ?
- 3) What are the income elasticities of the energy used ?
- 4) How does energy utilization in SA compare to that in other countries ?
- 5) Does the type of dwelling affect energy consumption ?
- 6) What is the energy used for, in what volume and at what cost ?
- 7) What is the total energy use and cost, per fuel type used in second (sic) world dwellings in the Cape Peninsula ?

#### 3.4.2 The Questionnaire and Interviewers

The questionnaire used in the initial survey is set out in Appendix 1. This questionnaire had the following problems:-

- 1) No date or time of interview is given.
- 2) Case numbering was not sequential and not unique.
- 3) The use of tabulation led to errors of incorrectly placed replies.
- 4) The attitudinal questions lost relevance on translation to Xhosa.
- 5) The layout of the questionnaire led to repetition and unnecessary length.
- 6) The direct questions on income probably elicited false replies, particularly from male respondents.
- 7) The lack of socio-economic information limits the use of the data collected, although it must be added that the original intention was to investigate income elasticities.

Students were used as interviewers. The HSRC (1988) notes that students generally often do not make satisfactory interviewers and in the initial survey this proved to be the case with some of interviewers. By backchecking by means of subsequent surveys of respondents of the initial survey it was found that a high percentage had not been interviewed, as set out in detail below. In addition data was missing on many questionnaires. As a result the data was suspect and required validation.

### 3.4.3 Survey date, areas and sample sizes

The survey was carried out in Winter 1987, between the months of May and August, and Summer 1987/8, between the months of October and May. As no dates were given on the questionnaire the exact date cannot be ascertained. A further major drawback is that the summer and winter samples were different and thus time-series data on the same respondents could not be collected.

The areas chosen for the initial survey were the formal black townships of Cape town, namely ; Langa, Gugulethu, Nyanga and Khayelitsha village. In addition some informal areas of Khayelitsha were chosen. For the identification of the frame the population of the formal areas was obtained from official figures and that of Khayelitsha by estimating the number of dwellings and applying an occupancy factor.

A random sampling technique was used whereby each dwelling was numbered and then random numbers selected. The HSRC (1988) notes that this technique does not give a completely spatially random sample. It was also found that only respondents in the main dwellings had been interviewed and as a result the large number of backyard shack dwellers with different socio-economic characteristics had been missed.

The table below sets out the number of returns in each area.

TABLE 3.1 INITIAL SURVEY.

AREA	SUMMER SAMPLE	WINTER SAMPLE	TOTAL SAMPLE	ESTIMATED HOUSEHOLDS
Langa	41	30	71	3 060
Nyanga	54	29	83	2 400
Nyanga West	-	28	28	1 000*
Gugulethu	92	63	155	8 484
Khayelitsha - formal	111	50	161	5 000
Khayelitsha - informal	-	55	55	15 000*
TOTAL	298	255	553	

\* Estimate (see also chapter 5)



#### 3.4.4 Coding, data entry and statistical manipulation

The initial survey was coded in part by the originators of the project and in part by the author. Data entry was initially by means of punch cards but this was replaced by direct entry on a Mohawk terminal by operators. Data 'cleaning' and statistical manipulations were carried out by means of the BMDP statistical package on the UCT Sperry mainframe.

#### 3.4.5 Summary of data

The numeric variables of the initial survey are summarised in Appendix 4.

### 3.5 THE FOLLOW-UP SURVEY

#### 3.5.1 Objectives

The objectives of the Cape component of the follow-up survey were as follows:-

- 1) To backcheck a sample of the initial survey to ascertain what proportion of the interviews had in fact been carried out.
- 2) To compare results and form a time-series data base where respondents had been interviewed before.
- 3) To interview shack dwellers in the formal townships and ascertain whether the results of the initial survey were skewed.
- 4) To increase the number of respondents in the informal areas covered in the initial survey.
- 5) To survey the larger informal areas not covered by the initial survey, namely; Khayelitsha site C, "Greenpoint", "Lusaka" and Crossroads.
- 6) To establish socio-economic data on the families in the survey.
- 7) To establish data on migration rates and periods of occupancy.
- 8) To provide the basis for a further detailed questionnaire.

The objectives of the Transvaal survey were to broaden the scope of the study and to compare energy usage and other data between the informal areas of the Cape and Transvaal.

#### 3.5.2 The Questionnaire and interviewers

A new questionnaire was developed that adopted the core questions of the initial survey but added questions on origin, migration, age, employment, expenditure and other factors. The questionnaire attempted to simplify work in the field and as a result was post-coded rather than pre-coded. This allowed the questionnaire to be dealt with in a shorter time although more data was collected than in the initial survey. In addition an attempt was made to rectify the perceived shortcoming of the initial survey in terms of

direct questions on income by use of income categories and income checks in the form of expenditure questions. The attitudinal questions were also modified to allow unprompted replies. The questionnaire was piloted in the Transvaal. This same questionnaire was used in both the Transvaal and follow up surveys and is set out in Appendix 2.

In both the Transvaal and the Cape a single full time interviewer was used. This permitted the author to accompany the interviewer where possible and to check all returns on a daily basis. Using a single interviewer has however the drawback of not being able to compare returns from different interviewers to establish personal bias.

In the Transvaal the interviewer was a man from Moutse who was highly qualified (unemployed school teacher) and with some experience in interviews for the CSIR. In the Cape the interviewer was a Xhosa woman who was a professional interviewer for the HSRC. The experience of the interviewers was reflected in the number of completed returns (100% in both surveys) and the low level of missing data, under 4% in both cases. The high quality of fieldwork and constant monitoring resulted in a body of data with a high level of confidence.

### 3.5.3 Survey dates, areas, sample sizes and randomizing techniques

The Transvaal survey was carried out in August and September 1988, over a period of both cold and warm weather. The survey in the Cape was carried out from October to December 1988, again under a variety of weather conditions.

A large sample in a single area was chosen in the Transvaal as the level of confidence in the data was more important than the need to cover all areas which was beyond the budget of the survey in any event. The area chosen was a new and rapidly growing informal settlement known as "Dunusa" or "Pola Park". The speed of growth had outstripped the numbering procedure of the local authority who in any case had no map of the area or an accurate population figure. The sampling technique consisted of ascertaining as accurately as possible the number of shacks and then interviewing every 20th shack. Shacks were returned to until a respondent was available. Where no respondent was available that number in the series was abandoned. Respondents were where possible the head of household or alternatively the person (generally a woman) who did the cooking.

In the Cape the address set of the initial survey was the frame in the formal areas and for a small part of the informal area. Thus where the survey was a backcheck the sample was a stratified one within the original random sample, obtained by using every  $n$ th original address - the sample obtained is thus random. The value of  $n$  varied from 3 to 5. In the areas which had not been dealt with in the initial survey a randomizing procedure of selecting blocks (after a sketch plan had been prepared) as per the HSRC (1988) technique was followed.

The table below sets out the areas covered in the survey and the number of returns.

TABLE 3.2 THE FOLLOW-UP SURVEY - CAPE

GROUPING	SUBTOTAL	%	AREA	RETURNS	%
Old Formal			Langa	23	12,8
			Gugulethu	22	12,2
	57	31,7	Nyanga	5	2,8
New Formal			Khayelitsha village	40	22,2
	46	25,6	New Crossroads	6	3,3
Old informal			Khayelitsha Site B	19	10,6
			Khayelitsha Site C	20	11,1
	49	27,2	Old Crossroads	10	5,6
New informal	34		Khayelitsha 'Greenpoint'	34	18,9
		18,9	"Lusaka" Squatter Camp	10	5,6
TOTAL	180	100,0		180	100,0

The Transvaal survey covered 67 respondents. The area is treated as a separate entity.

#### 3.5.4 Coding, data entry and statistical manipulation

In contrast to the initial survey the data was post-coded. Data was entered directly by the author onto diskette on a micro-computer. Statistical manipulation was by means of the "Statgraphics" package of the information technology library.

#### 3.5.5 Summary of data

The numeric variables of the follow-up survey are summarised in Appendix 4.

### 3.6 FUEL VENDOR SURVEYS

The distribution networks of various types of fuel were the subject of three further brief structured questionnaire surveys. The objective of this exercise was to obtain information that was not uncovered in the domestic environment of the follow up survey. The networks under study were;-

#### 1) Wood Gatherers.

This questionnaire focusses attention on wood which, contrary to expectations, is not widely used as fuel. Some 10 women were interviewed and their bundles weighed and measured. The survey should be considered a pilot study and may not be fully representative.



## 2) Paraffin Sellers.

The paraffin distribution network is large and diffuse. As a result only a small part of the informal area of Khayelitsha was covered and 10 vendors of the fuel ranging from individuals to shop owners were interviewed. As some aspects of the network had been uncovered during the course of the follow up survey the level of confidence in this small survey is relatively high.

## 3) Gas Merchants.

As for the above surveys 10 interviews were carried out, in this case on gas merchants. The survey covered a slightly larger area of Khyalitsha than that for the paraffin sellers with some interviews in the formal areas. As the gas distribution system is relatively highly structured some confidence may be placed in the results.

The questionnaires used are set out in Appendix 3.

### 3.7 THE ELECTRICITY SURVEY

The electrified households of Langa and Gugulethu formed the basis of an in-depth survey of electricity consumption patterns, patterns of disconnections and of outstanding balances. This data was supplied by the City Council of Cape Town, as read from meters and from recorded data.

### 3.8 DISTRIBUTIONS AND CHOICE OF STATISTICAL TECHNIQUES

Chi-squared tests were conducted on all of the numeric variables to test the fit against normal curves. Age, family size, number of adults per family, income and electricity expenditure exhibited small significance levels while the remaining variables had zero. None of the curves could be considered to approach normal. This was corroborated by a visual check which showed a wide scatter of the data.

As a result of these attributes non-parametric statistical techniques were the primary analytical tools used in the analyses but these were backed up with parametric techniques where the interpretation of both techniques provided additional insight. Where non-parametric correlation procedures are followed the Spearman rank correlation procedure is used. This correlation technique is less powerful than the parametric Pearson correlation technique but is applicable regardless of the underlying distribution. The Spearman rank correlation coefficient has a power-efficiency of 91% in relation to the Pearson correlation coefficient. That is, it is 91% as efficient at rejecting the null hypothesis.

### 3.9 CATEGORIZATION

A primary categorization of the Cape survey by settlement type was carried out with the categories as follows:-

- a) Old formal - The older established black townships of Langa, Nyanga and Gugulethu.
- b) New formal - The new black townships of Khayelitsha village (Kulani Park) and New Crossroads.
- c) Old informal - The older squatter areas of Site B, Site C and Old Crossroads.
- d) New informal - The recent squatter areas of "Lusaka" and "Greenpoint".

The Transvaal survey was on a single area which fell into category d).

As will be seen in chapter 5 there are substantial differences in all socio-economic characteristics between the areas, indicating the validity of this primary spatial categorization. Further categorization in terms of the character variables was then carried out and groups based on these variables as well as the numeric and transformed variables were generated.

### 3.10 A NOTE ON DESCRIPTIVE TERMINOLOGY

The processes and relationships revealed in the analysis below have to be described. These descriptions are qualified as they depend on measures of central tendency and inexact as language cannot convey the precision of numbers. An example from no less an authority than Keynes (1936:94) indicates that this is general problem. In the quote below he sets out "Engels law" which is described in 3.1 above.

*"The fundamental psychological law, upon which we are entitled to depend with great confidence both a priori from our knowledge of human nature and from the detailed facts of experience, is that men are disposed, as a rule and on the average, to increase their consumption as their income increases, but not by as much as the increase in their income."*

The terms in question are underlined.

## CHAPTER 4

### ENERGY CONSUMPTION AND TRANSITION IN SOUTHERN AFRICA: ANALYSIS OF EXISTING DATA

#### PART A: ENERGY CONSUMPTION AND TRANSITION IN SUB-SAHARAN AFRICA

##### 4.1 OBJECTIVES AND SCOPE

The objectives of this chapter are to assess some cross-sectional and time-series data available for certain African countries, and to investigate the consumption patterns for indications of energy transition at a national scale.

Due to the limitations of data 14 countries were selected for the initial investigation of macro-economic relationships. A more detailed analysis of 5 countries then follows. At this level of analysis energy consumption is still dealt with in aggregate but the domestic sector is the main focus of the investigation. Finally an in-depth analysis is carried out on a single country, Zimbabwe, with only the domestic sector being considered.

##### 4.2 LIMITATIONS OF DATA

The data available should be treated with caution. As the United Nations (1986:v) notes "Significant inadequacies, particularly in the coverage of traditional forms of energy and energy use, still have to be overcome."

The problem is compounded when dealing with the domestic sector wherein reporting of energy use is at best haphazard. Traditional fuels are wood, dung and crop wastes.

##### 4.3 DATA USED

On the basis of availability of energy data (United Nations, 1983, 1985, 1987) and socio-demographic data (Africa Insight, 1987) 14 Sub-Saharan African countries were selected for analysis.

The socio-demographic variables selected for analysis were; 1985 total population; 1970-1980 growth rates of the total population and urban population; 1985 urban population; 1985 percentage urbanized; 1985 per capita GNP and GNP growth for the period 1973-1980 or parts thereof. GDP would have been preferable but data was not available for all the countries in question. The influence of exports on the GNP should be borne in mind.

The energy related variables were the 1985 quantities and the 1970-1980 growth rates of the consumption of - a) total commercial energy, b) electricity, c) woodfuel and d) paraffin. These variables were transformed, inter alia, to give net energy per capita for each of the fuels. The countries selected and socio-demographic characteristics are tabulated below.

TABLE 4.1 SOCIO-DEMOGRAPHIC CHARACTERISTICS OF 14  
SELECTED SUB-SAHARAN AFRICAN COUNTRIES

COUNTRY	TOTAL POP mill	POP GROWTH % p.a.	URBAN -IZED %	URBAN GROWTH % p.a.	GNP/ CAP \$	GNP/CAP GROWTH % p.a.
ANGOLA	9,2	3,1	25	6,8	470	-9,6
CAMEROON	10,3	3,2	42	7,9	810	3,8
GHANA	14,0	2,7	40	5,0	390	-3,1
IV COAST	10,3	4,3	44	7,2	620	-1,1
KENYA	23,0	4,0	40	7,5	290	0,3
MALAWI	7,7	3,1	11	7,7	170	-0,4
MOZAMBIQUE	15,0	4,6	11	13,1	270	-5,3
NIGERIA	105,0	2,8	23	5,7	760	-2,5
S LEONE	4,0	2,1	28	4,6	370	-0,2
S.A.C.U.	40,0	3,0	52	3,3	2010	0,0
TANZANIA	24,0	3,4	15	9,0	270	-1,6
ZAIRE	34,0	3,0	44	5,5	170	-3,8
ZAMBIA	7,4	3,2	42	6,6	400	-2,6
ZIMBABWE	9,3	3,2	27	6,0	650	0,0

NOTE S.A.C.U - South African Customs Union

The negative growth rates of the GNP are a feature of the table, as are the high rates of population and urban growth. It is significant that South Africa, which is identified internally as having 'rapid urbanization' is ranked last in this respect.

#### 4.4 CORRELATION ANALYSES

##### 4.4.1 Relationships between socio-demographic variables

A Spearman rank correlation analysis of the relationships between the socio-demographic variables indicates the following:-

i) There is a very strong relationship (correlation coefficient 0,81) between the population growth rate and the urban growth rate. This may indicate that both natural increase is a major factor in urban growth, and that rapid rural population growth stimulates rural-urban migration.

ii) There is a negative relationship (correlation coefficient -0,51) between the level of urbanization and the rate of urban growth. This is to be expected in terms of the dynamics of urbanization where high growth rates are attainable at the early stages of the process (see Ledent, 1982).



There are, significantly, no correlations with the GNP or GNP growth and other socio-demographic variables.

#### 4.4.2 Relationships between the socio-demographic and fuel variables

The results of the correlation analysis (Spearman Rank) are given in the table below:-

TABLE 4.2 CORRELATION ANALYSIS - 14 AFRICAN COUNTRIES

ENERGY VARIABLES	SOCIO-DEMOGRAPHIC VARIABLES			
	POP GROWTH	% URB -IZED	URB GROWTH	GNP/ CAP
A. FUEL CONSUMPTION/CAP				
Woodfuel		-,42*		-,48
Paraffin		,37*		,48*
Electricity		,66	-,36*	,66
B. GROWTH OF FUEL CONSUMPTION/CAP				
Wood growth	,63		,42*	-,42*
Electricity				,66

Spearman rank correlation coefficients. Levels of significance + 95% except \* level of significance 85% to 95%.

The strong correlation of total population growth rate and the growth rate of wood fuel is indicative of the reliance of most of Sub-Saharan Africa on traditional fuels and a confirmation of the reality of the woodfuel crisis in this region.

The energy transition process is reflected in the influence of the level of urbanization on the per capita consumption of wood, paraffin and electricity. While the levels of significance are not high enough to draw firm conclusions the indications are that in countries with higher levels of urbanization there is a shift away from woodfuel to paraffin and electricity.

On the other hand however it appears that when the rate of urban growth is high the per capita consumption of woodfuel is also higher while that of electricity is lower - bearing in mind that the urban growth rate and levels of urbanization are negatively correlated. Again, the levels of significance are not high enough to draw firm conclusions, but the finding is in line with the general decline in the level of services in many rapidly growing African towns (see also Potter (1985) in this regard). It should be noted that South Africa is no different in this regard. On a per capita basis of all urban South Africans electricity consumption has also declined over the last decade.

The table illustrates the pervasive influence of the level of the GNP per capita on the consumption and rate of increase of consumption of fuels. In

the case of woodfuel there is a negative correlation with the GNP per capita suggesting that the transition from this fuel is also dependent on the creation of wealth, rather than the move to cities alone. The growth rate of the GNP per capita is not related to the fuel variables in question.

#### 4.4.3 Relationships between fuel variables

The fuel variables correlate to each other in some cases as follows.

- i) There is a strong negative correlation, correlation coefficient  $-0,61$  at significance level 97%, between the per capita consumption of wood and of electricity. This is an indication of the energy transition process, but, as will be seen below the shift is via transitional fuels rather than directly from wood to electricity.
- ii) There is a strong positive correlation, correlation coefficient  $0,60$  at significance level 97%, between the per capita consumption of paraffin and growth rate of the consumption of this fuel. This suggests increasing rapidity of adoption of this fuel as it becomes more readily available.

#### 4.5 INDICATIONS OF THE ENERGY TRANSITION PROCESS

While the sample is small the results suggest that in Sub-Saharan Africa there are indications of an energy transition process. This process is the shift away from woodfuel to the use of paraffin and electricity. The process is influenced by both urbanization level and the level of economic development of a country (as measured by GNP/capita) but does not appear to be influenced by the rate of growth of the GNP per capita. The population growth rate and the urban growth rate are closely linked (see above) and high rates of these variables stimulate the further consumption of woodfuel.

The results must be seen in the light of severe data limitations on the one hand, and a decade of general economic decline in Sub-Saharan Africa, as evinced in table 4.1, on the other. The expected shift to transitional fuels, in this case paraffin, is not as significant as expected. A deeper analysis is required to uncover the role of these transitional fuels.

#### 4.6 ENERGY CONSUMPTION AND TRANSITION IN THE DOMESTIC SECTOR

The analysis at this point focusses on the domestic sectors of 5 countries, namely Kenya, Malawi, Nigeria, Zambia and Zimbabwe.

The importance of the domestic sector in the energy balances of the countries in question is graphically illustrated in figure 4.1 overleaf. Even in Nigeria the domestic sector accounts for more than 60% of the total energy consumed. In Zambia the relatively large amounts of energy consumed by the

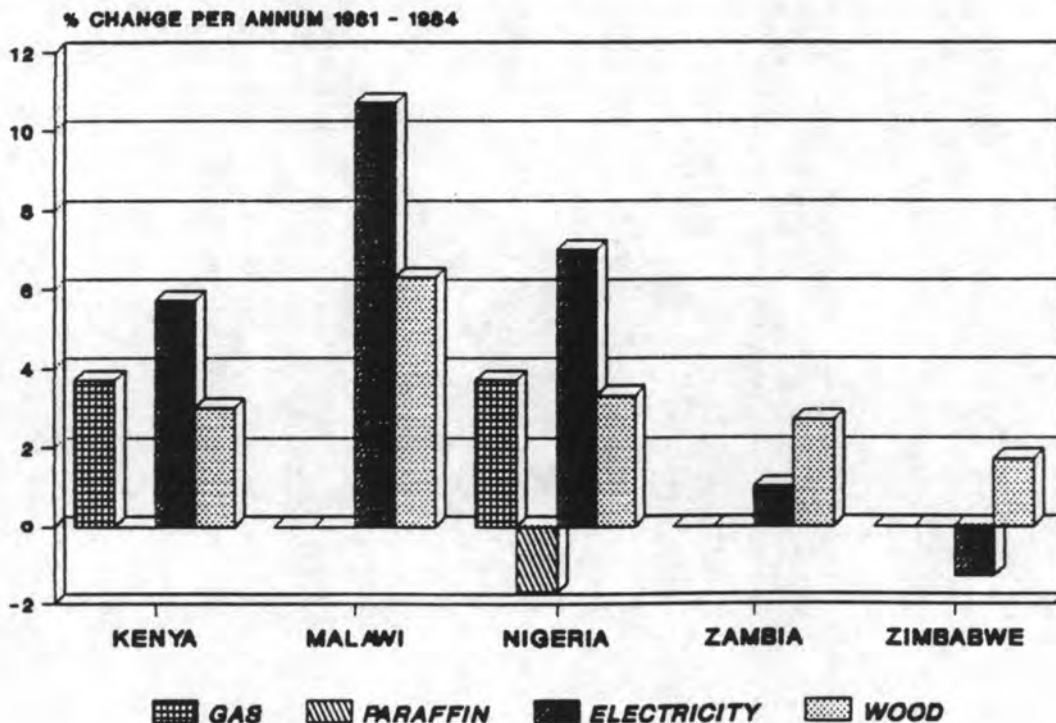


mines distorts the picture. Malawi is representative of the poorer African nations with the domestic sector accounting for 84% of the total energy consumed. In all these countries traditional fuels are of overwhelming importance in the domestic sector. As a proportion of the total net energy consumption in this sector they accounted for 99,2% in Malawi, 97,8% in Kenya, 96,3% in Zambia, 93,2% in Zimbabwe and 94,8% in Nigeria.

The change in total energy consumption, by fuel, for 5 of the countries in question, for a 4 year period from 1981 to 1984 is illustrated in figure 4.2 below. Although the time series data on which the figure is based is limited several factors are apparent. Firstly, woodfuel consumption increased in all the countries in question. Secondly, electricity is the fuel that posts the highest growth rates. Thirdly, of the transitional fuels, gas shows positive growth rates in only two countries. Paraffin shows no growth and in fact shows a decline in Nigeria, an oil producing country.

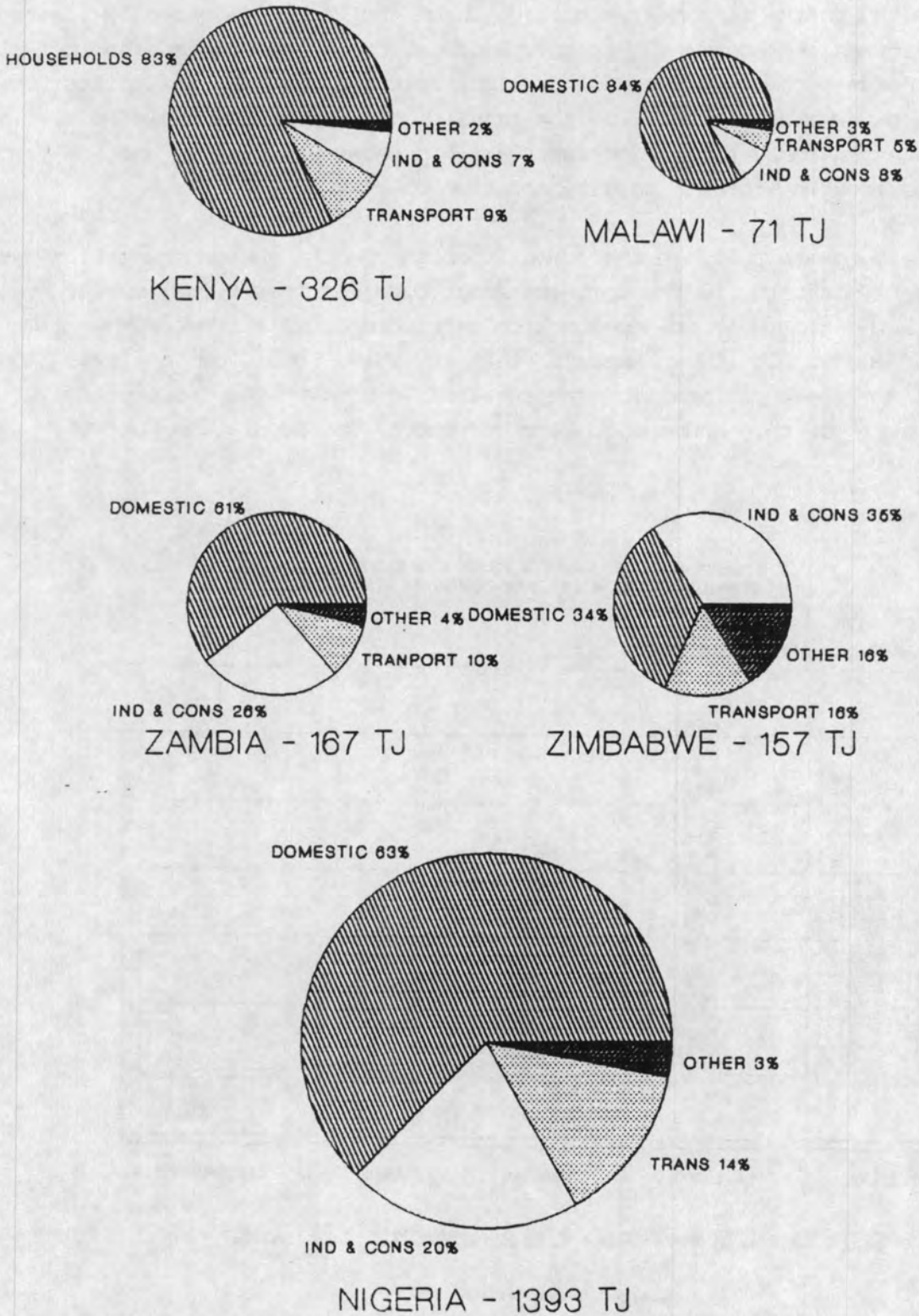
The figure suggests that, in the domestic sector, where energy transition is occurring, electricity is the dominant substitute for traditional fuels. Even in Nigeria the growth in the consumption of electricity is greater than that of liquid fuels. It thus appears that at this level of analysis the indications of energy transition are erratic. To uncover the process analysis at the level of the household, and corrected for population growth, is required.

**FIGURE 4.2 CHANGES IN TOTAL NET ENERGY CONSUMPTION: 5 AFRICAN COUNTRIES 1981/4**



Source: United Nations, 1986

FIGURE 4.1 ENERGY CONSUMPTION BY SECTOR  
FIVE AFRICAN COUNTRIES 1984



#### 4.7 THE CASE OF ZIMBABWE

Zimbabwe is important for comparison purposes with South Africa. It is relatively highly industrialised (second in Sub-Saharan Africa) but has an urbanization level of roughly half that of South Africa. It may be assumed that the energy transition process in Zimbabwe is, at any given time, at a less advanced stage than in South Africa.

The 1986 UN data for energy consumption in Zimbabwe for the period 1981 to 1984 is tabulated below.

TABLE 4.3 NET ENERGY CONSUMPTION BY HOUSEHOLDS IN ZIMBABWE  
1981-84 TERAJOULES PER ANNUM

	1981	1982	1983	1984
	TJ	TJ	TJ	TJ
COAL	0	0	0	0
LPP	0	0	0	0
LPG	182	228	182	182
ELEC	3 572	3 562	3 342	3 425
TRAD	47 161	48 841	47 864	49 329
TOT	50 916	52 630	51 388	52 936

Source. UNITED NATIONS, 1986.

This data should be compared with those of Hosier (1986) whose data is based on a National household energy survey undertaken by the Zimbabwe Central Statistical Office in 1984. The sample consisted of 5000 households of which over 80% were in rural areas. This data is likely to be much more accurate than the UN figures quoted above. As can be seen there is a huge disparity between the 113 440 TJ total of this data and the 52 936 TJ total of the UN data for 1984.

TABLE 4.4 NET ENERGY CONSUMPTION IN THE DOMESTIC SECTOR OF ZIMBABWE.  
1984. TERAJOULES PER ANNUM.

	RURAL		LOW DENSITY URBAN		HIGH DENSITY URBAN		TOTAL	
	TJ	%	TJ	%	TJ	%	TJ	%
COAL	2 700	2,6	0	0	700	17,1	3 400	3,0
PARAFFIN	740	0,7	100	2,8	150	3,7	990	0,9
GAS	0	0	10	0,3	10	0,2	20	0,0
ELEC (Dom)	130	0,1	2 570	73,0	880	21,5	3 580	3,1
FUELWOOD	102 260	96,6	840	23,9	2 350	57,5	105 450	93,0
TOTAL	105 830		3 520		4 090		113 440	
	(93,3%)		(3,1%)		(3,6%)		(100%)	

(Source. Hosier 1986)



The huge differences in patterns of energy consumption between rural and urban areas are evident - for the year in question some 24% of Zimbabwe's population lived in urban areas but consumed only 6,7% of the domestic sector total net energy. The high density areas consist of the townships and informal areas and house some 230 thousand households which is 67% of the urban total. The net energy consumption per household in these areas was 17,8 GJ per annum. The low density areas consist largely of the well serviced formerly white suburban areas and house some 114 thousand households. These low density areas consumed 31 GJ per household per annum. The 1.16 million rural households consumed 91,6 GJ per household per annum. These figures clearly reflect the relative efficiencies of the energy conversion appliances, mainly for cooking and heating, of the various areas.

The table is significant as it clearly illustrates the energy transition process in cross-sectional data terms on the basis of a large survey. Woodfuel is obviously critical throughout the domestic sector. In the high density urban areas coal is adopted as a transitional fuel and there is a shift to electricity. In the low density areas which are the most affluent coal is abandoned and electricity is predominant but there is still a high usage of wood, possibly as it is used for space heating and by domestic servants in these areas. The transition in Zimbabwe is thus an urban phenomena as in South Africa.

The figures for paraffin and gas, both important transitional fuels, are strikingly low. With reference to rural paraffin use Harlen and David (1983) state "About 95% of rural homes use paraffin for lighting and the average annual consumption is about 40 litres. This is a national total of 30 million litres per annum" (p104). With reference to the urban areas they note that the percentage fuel use by frequency of use was as follows; paraffin 43%, wood 38%, electricity 16%, coal 1,6%, LPG 1%. They also note, "Urban households that use paraffin use a great deal more (160 litres/annum) than rural households because it is used for both cooking and lighting." (p105).

On the basis of these frequency and consumption figures, and some 230 thousand high density urban households, the net energy consumption from paraffin would be 554 TJ in the high density areas alone, compared to 150 TJ reported by Hosier (ibid). Similarly, for the rural areas the consumption figure translates into 1050 TJ per annum, some 40% higher than the figure of Hosier (ibid). If this figure is correct it suggests that a major domestic transition to paraffin has taken place unnoticed - possibly as a result of sectorial bias i.e. allocating paraffin use to the agricultural and commercial sectors rather than the domestic, and also as a result of the difficulty of assessing end users. As important, it illustrates the unreliability of published data at the macro-level as the UN figures record no usage of paraffin or coal in Zimbabwe in 1984. It also indicates the sensitivity of national consumption figures to the average consumption figures derived from micro-level energy studies.



## PART B - SOUTH AFRICA

### 4.8 OBJECTIVES AND DATA SOURCES

The objectives of this section are the continuation of the analysis of energy transition at a national scale with South Africa as the country under study.

For the purposes of analysis several sources of data were considered, whether the collecting of energy related statistics was the overt aim or not. However no claim is laid to universality and certain studies were not used while others may have been overlooked.

### 4.9 DATA FROM INCOME & EXPENDITURE REPORTS OF BUREAU OF MARKET RESEARCH UNIVERSITY OF SOUTH AFRICA

#### 4.9.1 General statistics.

The Bureau of Market Research of the University of South Africa (BMR) has prepared income and expenditure reports on the various sectors of the population since 1960. While the data collection techniques (long and complex questionnaires) and the disaggregation of some of the data may be questioned, taken as a whole the data set represents a large and often overlooked resource. For any investigation of South Africa at the national or regional scale it represents an excellent departure point.

The format of the questionnaire used has remained relatively unchanged and hence time-series data analysis is possible. The BMR reports are aimed at the business market and hence reportage on energy related items is not paramount. The 'Fuel and Light' category is however of great interest. A major problem encountered is the aggregation of housing and electricity and the lack of data on the number of electrified dwellings. The older reports disaggregate the usage of fuel and light by income, but later reports do not, and indeed do not provide any detailed reporting on this category - an indication of it's perceived decline in importance ?

Table 4.5 overleaf summarises certain demographic and socio-economic data from various reports.

The following observations may be made concerning these data.

1. The motivation to urbanize is clear from any rural-urban comparison of income for the same year.
2. The problem of poverty, particularly in the rural areas, is encapsulated by the very low income figures.
3. The income figures that are discounted for inflation for the Western Cape show a drop in the mean household income from 1975 to 1985.

TABLE 4.5 SUMMARY OF VARIOUS BMR SURVEYS. MULTIPLE BLACK HOUSEHOLDS

A. URBAN AREAS

METRO AREA	DATE	SAMP SIZE	FAM SIZ	EMP RAT	INC H/H	INC CAP	INC EMP	EXP F&C %	EXP HSE %	EXP TRN %	EXP F&L %
W CAPE	1970	200	5,9	.26	<u>117</u>	20	73	56	6	5	2,6
	1972	214	5,9	.28	22	3,7	13	55	6	5	2,6
	1975		5,7	.27	<u>136</u>	24	86	54	6	6	4,1
	1985		6,4	.22	130	20	81	44	9	11	1,5
PRET	1971	410	5,7	.28	18	3,2	10	48	8	7	3,2
	1980	400	6,2	.27	79	12,8	44	47	9	9	1,6
JHB	1971	320	5,1	.28	20	3,9	12	50	7	7	4,2
VAAL T	1980	300	4,95	.25	69	14	51	47	9	8	4,0
	1985	283	5,54					43	11	10	2,4
OFS G	1985	200	5,36	.28	140	26	88	41	12	9	2,1
DURBAN	1971	400	5,7		18	3,2	11	51	7	7	2,2
	1975	420	5,7	.27	30	5,3	8,4	56	4	6	3,3
PE	1972	324	5,3	.32	18	3,3	10	53	6	6	2,3
	1975	396	5,6	.29	37	6,5	22	54	6	6	2,7

B. RURAL & HOMELAND TOWN.

AREA	DATE	SAMP SIZE	FAM SIZ	EMP RAT	INC H/H	INC CAP	INC EMP	EXP F&C	EXP HSE	EXP TRN	EXP F&L
KWAND	1979		5,54					51	4	7	5,4
	1984	600	5,81					52	4	12	6,0
VENDA	1977	513	5,0	.23	16	3	13	57	9	2	3,7
	1980	522	5,1		20	4		58	8	3	3,9
GWAGWA	1981		5,5	.24	34	6	25	57	2	4	6,5
	1985	600	5,81	.24	74	13	52	47	6	5	6,1
BOP urb	1977	900	5,6		30	5		49	7	7	5,0
	rur							53	5	8	7,1
KANG	1980	598	6,0	.24	28	5	20	58	5	5	4,7

NOTE

1. Income per household (H/H), Per person (CAP) and Employed person (EMP) are per week.
2. Expenditure (EXP) on food & clothing (F&C), housing and electricity (HSE), transport (TRN) and fuel & light (F&L) are expressed as percentages of total expenditure
3. Underlined figures are discounted to 1985 costs.

4. There is an increase in mean household size in both urban and rural areas - the consequence of overcrowding rather than increased family size. (BMR 1986:10 notes "*chief among the reasons for this phenomena are the recession and housing shortages..*")
5. There is a decrease in the employment rate over time - the consequence of increased unemployment and the increasing importance of the informal sector. This is an indication of the "backwash urbanization" phenomenon.
6. In spite of the above, another indicator of welfare, the percentage of expenditure spent on food and clothing, has declined over time in the urban areas indicating increasing discretionary income.
7. The relative expenditure on housing (including electricity) and transport have both increased in time, indicating inter alia the increased real cost of energy.
8. The relative budget share of fuel and light in any one time period is substantially higher in the rural areas than in the metropolitan areas. This share would be further increased if non-commercial fuelwood was included. This indicates that the real "energy crisis" is still in the rural areas.
9. Although erratic, there has been a decline over time in the relative expenditure on fuel and light in the urban areas. This decline should be seen against the backdrop of the social indicators discussed above. In addition it should be borne in mind that shifts in one group can mask shifts in other groups. The shift to electricity, included in the housing category, could mask a relative increase in the fuel and light category of non-electrified households. In spite of this, from this data it would appear that in terms of current total household expenditure fuel is not a problem in the urban areas.
10. In the rural areas, in 2 out of 3 cases, there has been a small increase over time in the relative expenditure on fuel and light. Unchanged levels of poverty in these areas are an explanation.

Taken as whole a picture emerges of great regional economic disparity, of a slow and ambiguous increase in welfare in the metropolitan areas, and of a transition process in which the relative importance of fuel and light decline over time.

#### 4.9.2 Fuel use in the rural areas.

A cross-sectional comparison of fuel data from BMR reports for 3 "homeland" areas is presented in table 4.6 below. The data on wood must be treated with caution as it relates to commercially obtained wood and not collected fuelwood. It is significant however that the use of wood is in inverse relationship to the economic welfare of the area in question, as indicated by the income data in the previous table. The table is arranged in increasing 'urbanity', from the wholly rural areas to the wholly urban homeland areas. The use of wood decreases monotonically with increasing urbanity.



TABLE 4.6 RELATIVE EXPENDITURE ON FUELS. 1977.  
RURAL AREAS AND HOMELAND TOWNS

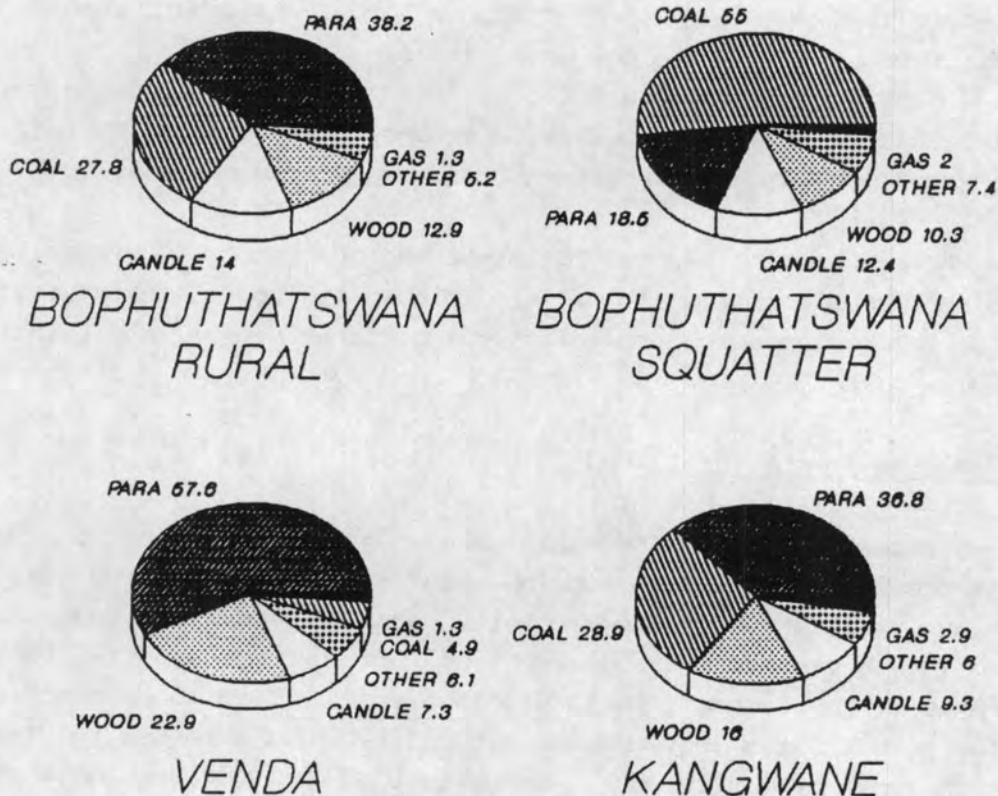
AREA		GAS %	COAL %	WOOD %	PARA %	CANDLE %	OTHER*
VENDA		1,3	4,9	22,9	57,6	7,3	5,9
KANGWANE		2,9	28,9	16,0	36,8	9,3	6,0
BOPUTHA-	Rural areas	1,3	27,8	12,9	38,2	14,0	4,9
TSWANA	Squatters	2,0	55,1	10,3	18,5	12,4	7,4
	Large town	1,0	53,1	11,5	20,3	11,1	2,8
	Total	0,9	41,4	11,8	28,8	12,9	4,0
TRANSKEI	Urban	1,9	42,5	11,3	27,2	12,4	2,6

\* Includes meths and match.

Paraffin is the major fuel in the wholly rural areas. Coal is the dominant fuel in the towns. The squatter areas of Bophuthatswana have a fuel use profile identical to the urban areas. The location of these areas adjacent to the 'border' and their function as rural dormitory areas must be borne in mind.

Four of these areas are indicated on figure 4.3.

FIGURE 4.3 PERCENTAGE EXPENDITURE ON FUELS IN RURAL AREAS. 1977





#### 4.9.3 Fuel use in the urban areas.

The data for the urban areas is tabulated below.

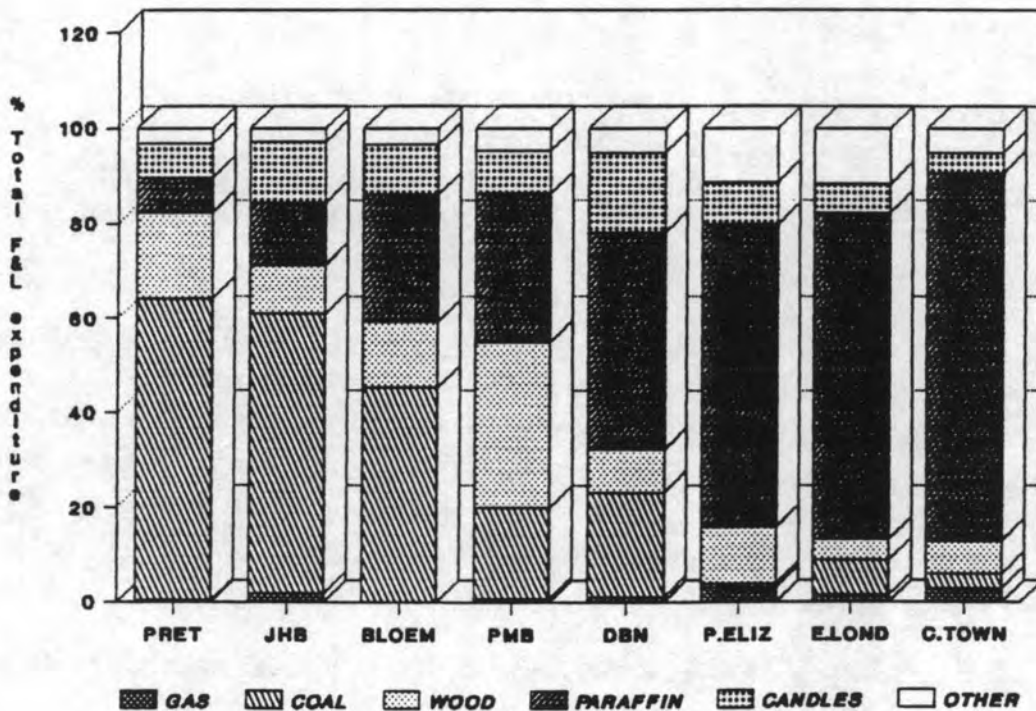
TABLE 4.7 RELATIVE EXPENDITURE ON FUELS. 1977.  
METROPOLITAN AREAS.

AREA	GAS %	COAL %	WOOD %	PARA %	CANDLE %	OTHER*
PRETORIA	0,4	63,8	17,9	7,5	7,2	3,2
JOHANNESBURG	1,8	59,2	10,3	12,9	12,9	2,9
BLOEMFONTEIN	-	45,3	14,0	26,6	10,6	3,6
PIETERMARITZBURG	0,7	19,3	35,0	31,2	9,1	4,9
DURBAN	1,1	22,2	9,0	45,7	16,8	5,0
PE / UITENHAGE	3,2	0,8	12,1	63,7	8,9	11,3
EAST LONDON	1,4	7,7	4,2	68,8	6,1	10,8
CAPE TOWN	2,9	3,2	7,0	77,5	4,2	5,3

\* Includes meths and match.

The relative importance of paraffin vis a vis coal is graphically illustrated in figure 4.4 below.

FIGURE 4.4: RELATIVE EXPENDITURE ON  
FUELS. URBAN AREAS. 1977



From this table and figure 4.4 above an inverse relationship between paraffin and coal use in the metropolitan areas is revealed. As a result a regional division into coal dominant and paraffin dominant regions is possible - with the Transvaal and Orange Free State falling into the former region and the Cape into the latter. Pietermaritzburg represents a different system where wood is still the dominant fuel. Expenditure on wood is generally higher in the coal dominant region than in the paraffin dominant region, possibly as it is used as kindling for coal fires, but the pattern is not clear-cut. At this stage, in 1977, gas was an insignificant item of expenditure, ranking on average below matches. Candles on the other hand were significant.

#### 4.9.4 Fuel usage by income group in Cape Town in 1972

The usage of black households of fuels in the 'fuel and light' category is disaggregated by income and end use in a BMR report for Cape Town for 1972, the last date at which this disaggregation was performed. The following salient points emerge from this document:-

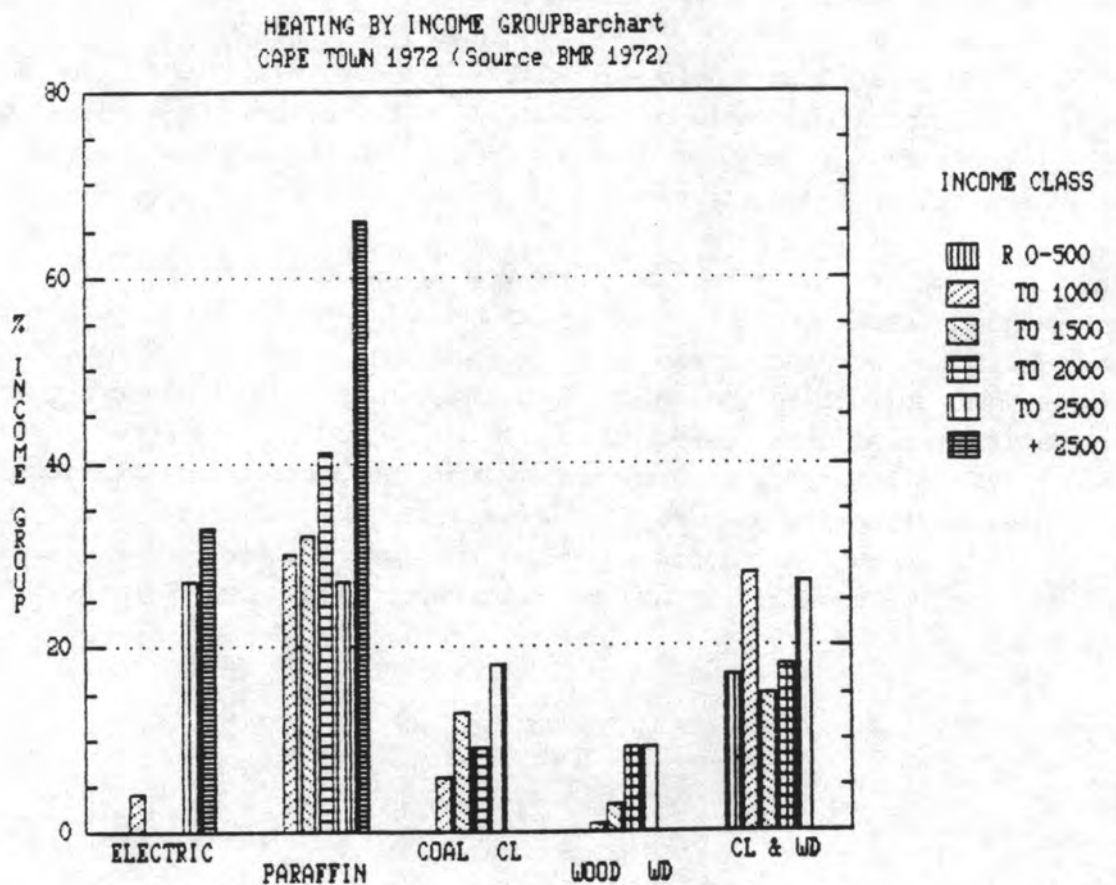
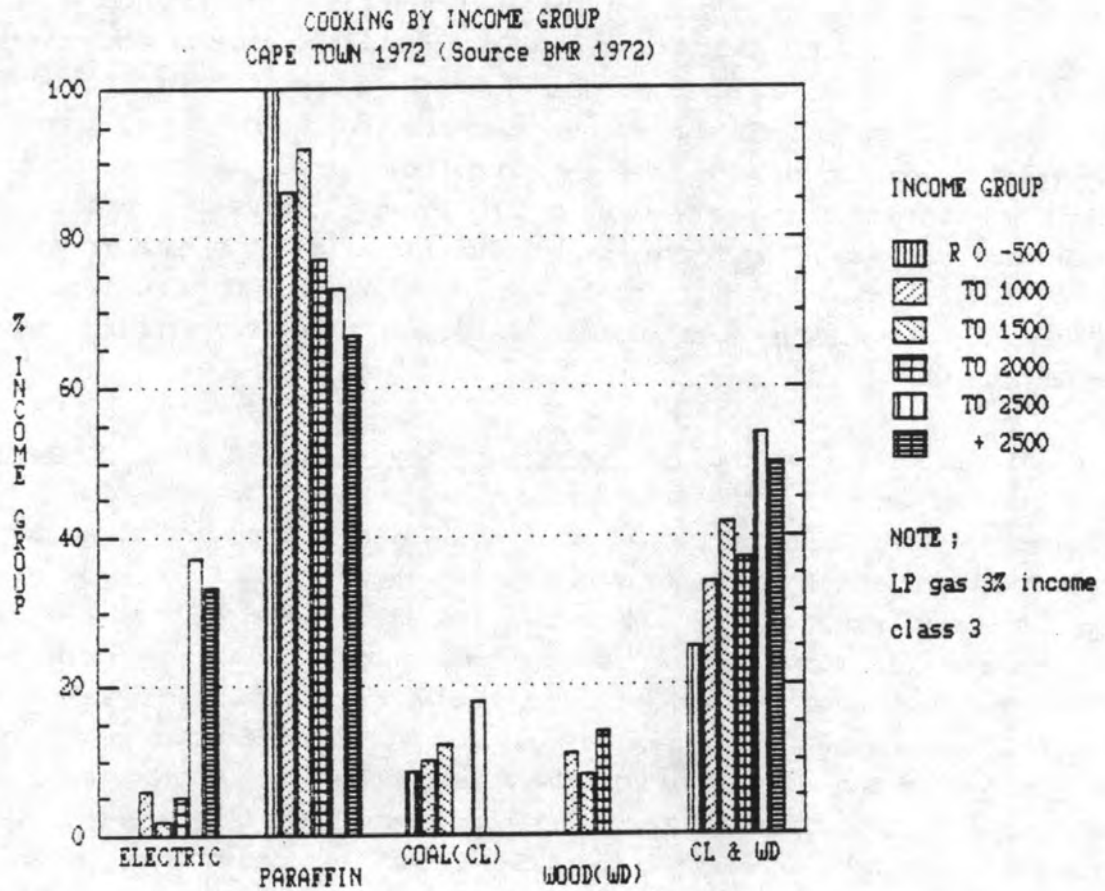
- 1) For lighting paraffin use falls off slightly as income increases, electricity use increases sharply while the use of candles is constant across the income range.
- 2) For heating paraffin use increases sharply in the highest income group. Electricity is only used to a significant degree in the last two income groups. The use of coal for heating increases with income, as does wood, although singly these fuels are of minor importance. Coal and wood combined are more important as a fuel, but with an erratic pattern of use by income group.
- 3) For cooking paraffin is used by 100% of the lowest income group, supplemented with coal or coal and wood combined. The use of paraffin declines sharply with income, as opposed to coal and coal and wood combined which increase. The use of electricity is only significant in the highest income groups.

From the above it is evident that paraffin is the dominant fuel for lighting, heating and cooking. As early as 1972 wood was already a minor fuel in the Cape, but coal and wood combined, with the wood probably used for kindling, were important fuels for cooking. Only in the case of cooking is a clear-cut substitution of fuels discernible, but even here paraffin remained the dominant fuel for the highest income group. It is noteworthy that in 1972 the use of gas was negligible.

While these figures are out of date they serve in the development of time series data for the understanding of the energy transition process.

Figure 4.5 below presents the data for heating and cooking.

FIGURE 4.5 FUEL USE BY INCOME. CAPE TOWN 1972  
COOKING AND HEATING. (Source BMR 1972)





#### 4.10 ENERGY STUDIES

As noted in the literature survey, the last decade has seen an increasing number of South African energy studies which focus attention on the use of energy by the populations in question. They highlight aspects not covered in general market research surveys, particularly energy consumption and fuel preferences. These energy studies have to date treated rural villages, small 'homeland' towns and in one case a metropolitan area, as their subjects. A wealth of information is available in these studies and while a full comparison is beyond the scope of this dissertation the data from several energy studies is compiled in table 4.8. A cautionary note must be sounded that the objectives and data collection techniques of the studies presented differ widely.

In all the studies reported use is made of several fuels simultaneously. For those studies reporting the data fuelwood and paraffin are the dominant fuels in terms of their frequency of use, the latter achieving close on full representation. In terms of expenditure the importance of fuelwood in rural areas is clear, ranging from 23% to 54%, but it is generally not the dominant fuel. However non-commercial fuels make up a proportion of the fuels used in rural areas and these are not included. Fuelwood in the urban areas is in the 10% to 20% range of the commercial fuel budget. Paraffin is some 35% of the fuel budget in the rural areas in the cases where other commercial fuels are used. In the urban areas paraffin ranges from 20% (where electricity is available) to 50% of the fuel budget. Dry batteries account for a significant proportion of all fuel costs, in all cases more than candles, indicating the penetration of battery driven appliances.

Unfortunately total household expenditure is not available and the share of fuel in the total household budget cannot be calculated. However, in terms of the proportion of household income spent on fuel there is an inverse relationship, as expected, between income and this proportion.

The broad pattern revealed by these energy studies is that of widespread commercialization of fuel wood in the rural areas and widespread use of paraffin. In the urban areas paraffin and coal are the dominant fuels and commercial fuelwood and gas minor fuels. Taken as whole these energy studies confirm the rural urban differences and the regional differences highlighted by the BMR data but no time-series analysis is possible. Indications of the energy transition process are thus unexplicit. When compared to the BMR data in detail however a number of questions are raised - particularly the significant differences in the expenditures on fuels found in recent energy studies.



TABLE 4.8 SUMMARY OF DATA FROM CERTAIN ENERGY STUDIES

A. PRELIMINARY DATA

NO	DATE	AREA	VILLAGE NAME	CLASS- IFICATION	NO RESP	H/H SIZE	H/H INC WK	FUEL AS % INC
1	1979	LESOT.	Malefiloane	rural	20	5,2	7,6	14,5
2	1986	SA	6 Villages	rural	231	-	-	-
3	1988	CISKEI	10 villages	rural	100	7,3	94,0	9,6
4a/b	1987	OFS	Botshabelo	resset.	200	6,5	79,3	11,4 a
5a/b	1987	OFS	Mangaung	town	100	6,9	96,4	9,8 a
6	1987	BOP.	Mafik/Mmab	town	55	6,8	47,7	13,9
7	1986	C.T.	Crossroads	metro	85	-	-	-
8	1988	CISKEI	5 towns	town	100	6,8	103,1	7,7
9	1986	TvL	Soweto	metro	60	-	672,67	-
10	1986	TvL	Soweto	metro	41	-	479,43	8,26*

B. % HOUSEHOLDS USING FUEL

STUDY NO*	FUEL WOOD	PARA- FFIN	COAL	GAS	ELEC	CAND	DRY BAT	CAR BAT	OTH ER
3	86	99	3	13	0	65	89	13	65
6	76	96	42	15	4	87	38	9	38
7	38	100	45	4	0	52	49	-	-
8	58	98	1	16	0	65	80	11	18
9	60	72	60	36	0	-	67	-	-
10	54	48	54	50	100	-	70	-	-

C. MEAN MONTHLY EXPENDITURE ON FUEL

STUDY NO	FUEL WOOD	PARA- FFIN	COAL	GAS	ELEC	CAND	DRY BAT	OTHER TOT
1	R	1,10						1,10
	%	-	100			?		-
2	R	8,80	5,59	1,86	0,76	0	1,71	-
	%	54	34	11	5	0	11	-
3	R	8,75	14,16	0,53	4,46	0	2,26	6,92 [37,038,88
	%	23	36	1	11	0	6	18 5 100
4a	R	3,96	14,95	5,64	3,75	0	3,94	6,50
	%	10	38	14	10	0	10	17
4b	R	12,02	15,37	18,52	3,55	0	4,50	6,61
	%	20	25	30	17	0	7	11
5a	R	3,36	11,44	4,96	1,24	10,30	2,48	6,94
	%	12	28	12	3	25	6	17
5b	R	8,68	12,18	16,45	1,76	12,50	2,68	6,81
	%	14	20	27	3	20	4	11
6	R	5,30	14,00	3,50	2,30	0	3,60	-
	%	19	49	12	8		13	
7	R	11,25	23,33	14,75	1,25	0	2,41	4,92
	%	19	40	25	2		4	
8	R	5,68	15,11	0	4,09	0	1,91	7,41
	%	16	44	0	12	0	6	21

D. MEAN ANNUAL HOUSEHOLD USEFUL ENERGY CONSUMPTION GJ/HOUSEHOLD

STUDY NO*	FUEL WOOD	PARAFFIN	COAL	GAS	ELEC	CAND	DRY BAT	OTHER	TOTAL
1	3,5	0,5						1,8	5,8
2	5,9	2,4	1,0	0,3	0	0,6		0,8	11,0
4a	0,27	6,0	1,3	0,9		?		?	8,5
4b	0,8	6,2	4,2	0,9		?		?	12,1
6	1,5	4,3	1,6	0,8	0	0,5	-	-	8,6
7	2,6	12,5	8,3	0,7	0	0,9			25,0

E. NOTES

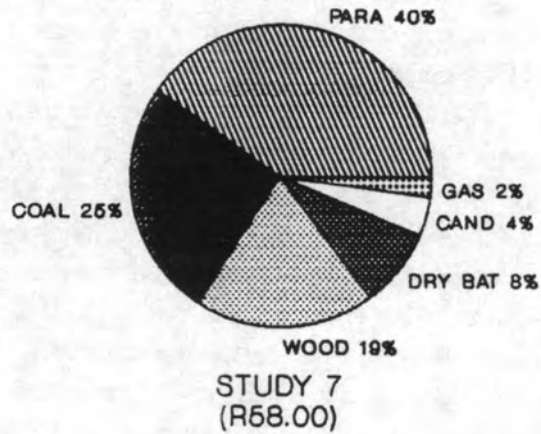
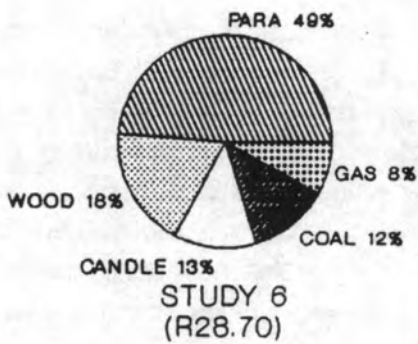
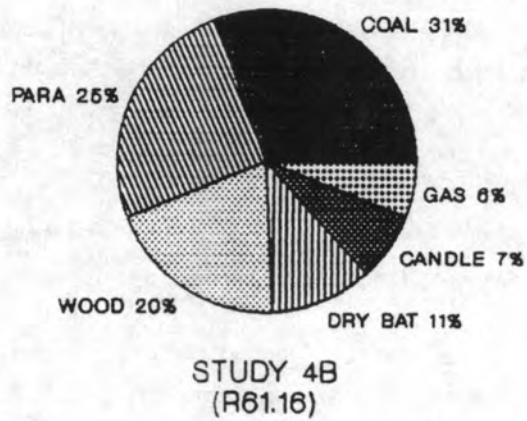
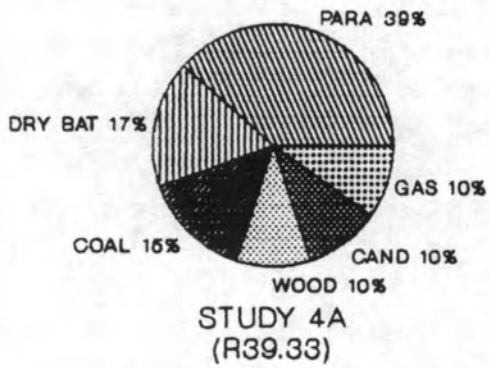
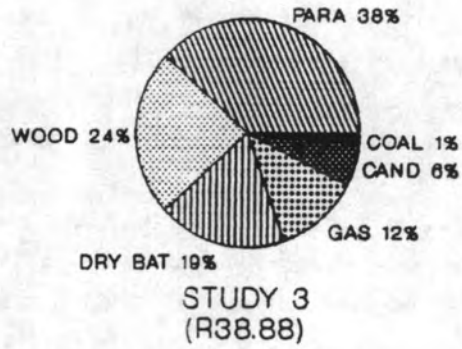
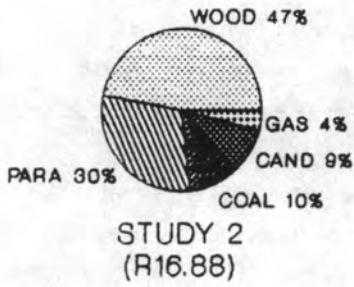
NO	REFERENCE	DATE	NOTES
1.	Best, M. (1979) Malefiloane	1979	Total pop. sampled
2.	Eberhard, A.A.	1986	Unweighted addition of samples
3.	Tobich R.G. & Dingley C.E.	1988	Villages in Ciskei
4a	Read Consultants	1987	Botshabelo summer
b	" "	1987	" winter
5a	Read Consultants	1987	Mangaung summer
b	" "	1987	" winter
6.	Eberhard A.A & Dickson, B.J.	1987	Mafikeng/Mmabatho peri-urban areas
7.	Eberhard, A.A.	1986	Crossroads only
8.	Tobich, R.G. & Dingley, C.E.	1988	Towns in Ciskei
9.	Gervais, J.H.	1986	Un electrified sample - income below R500
10.	" "	1986	Electrified sample - income below R500

F. FURTHER NOTES

- Means calculated over whole sample not within user group.
- Costs in rands at given date i.e. not discounted for inflation.
- Useful energy consumption calculated for 3a,b from given costs, assuming coalbag = 25kg and Woodbag = 20kg and efficiencies as below.
- Efficiencies for useful energy consumption - gas 75%, paraffin 50%, coal 20% and wood 10% (Source: A. Eberhard; Perscom).

Figure 4.6 overleaf presents the expenditure on fuels found in some of the energy studies. The study numbers relate to those in the table above.

**FIGURE 4.6 PERCENTAGE EXPENDITURE ON FUELS  
VARIOUS ENERGY STUDIES  
(SEE P 58 FOR REFERENCE NUMBERS)**



#### 4.11 CONCLUSIONS

From the study of domestic energy transition in South Africa at the national scale a number of tentative conclusions may be drawn.

Firstly, a division between coal and paraffin dominated regions may be made. This gives rise to the question as to whether the cost of coal in relation to paraffin, or some other variable, dictates the relationship between the use of these two fuels. As the relative share of coal in the household fuel budget falls in relation to the distance from the Transvaal coal mines, reflecting the high transport cost component of the fuel, a strong case can be made that the price variable is dominant.

Secondly, while there are wide ranges in the data, there are definite differences between rural and urban energy use patterns. In the former areas fuelwood plays a large role although it is not generally the dominant fuel in terms of expenditure. In the urban areas paraffin and coal are dominant.

Thirdly, the domestic energy transition process has developed further in the black population of South Africa than in other Sub-Saharan African countries. In the rural areas of South Africa commercialization of woodfuel and the use of paraffin is extensive while in the urban areas transitional fuels are dominant.

Comparison of the Bureau of Market Research Reports and the energy studies cited raise further questions.

1) Why is there a substantial difference between the proportion of fuel cost to total expenditure in the BMR reports, and the proportion of fuel cost to total income in the energy studies? A relationship between income and expenditure in the black areas under study could be expected yet the former studies give a range of fuel cost/total expenditure of 3,7% to 7,1%, while the energy studies give a range of fuel cost/mean income of 9,6% to 14,5%, for rural areas. The corresponding values for urban areas are 1,5% - 4,1% and 7,7% - 13,9%. The ratio of fuel costs/total expenditure should be higher than fuel costs/income and yet the reverse is indicated. These differences may be explained to some extent by differences in data collection - the BMA may be underreporting fuel costs while the energy study authors are overreporting these costs. Income data may also be underreported in the energy studies. The divergence of income and expenditure, alluded to in chapter 3, may in itself explain the differences.

2) Why is there a major difference in the proportion spent on coal in the Transkei to that in the Ciskei? The BMR reports 55% in the Transkei in 1977, compared to 0% in the Ciskei reported by Tobisch & Dingley (1988) in 1988? Similarly the BMR reports that the proportion spent in



the Bophuthatswana squatter areas in 1977 on coal was 55% while Eberhard and Dickson (1987) report 12% spent in 1987. An energy transition process away from coal would explain this phenomena although the rate is extremely high.

As indicated in Part A of this section the use of data at the macro-level only is inadequate to reveal the details of the domestic energy transition process. Energy studies are required to illuminate the process but at present these studies have a poor theoretical base and can give widely differing results as indicated by the two studies in Zimbabwe cited above.

Energy studies are as yet in their infancy in South Africa. The stress to date has been on statistics involving fuels while demographic and socio-economic data, which are essential to establish the functional relationships with the populations in question, are often missed. Also, sample populations have not been revisited to allow time-series data to be assembled. Finally, the focus of energy studies has been on rural areas - villages and towns, while the rapidly growing metropolitan areas (with the exception of Eberhard, 1984 & 1987) have been overlooked.

This dissertation attempts to redress the balance between rural and urban energy studies to a small extent and examines some of the questions posed above in greater detail.



## CHAPTER 5

### ANALYSIS OF THE FOLLOW-UP SURVEY PART1 - SOCIO-ECONOMIC DATA

#### 5.1 OBJECTIVES

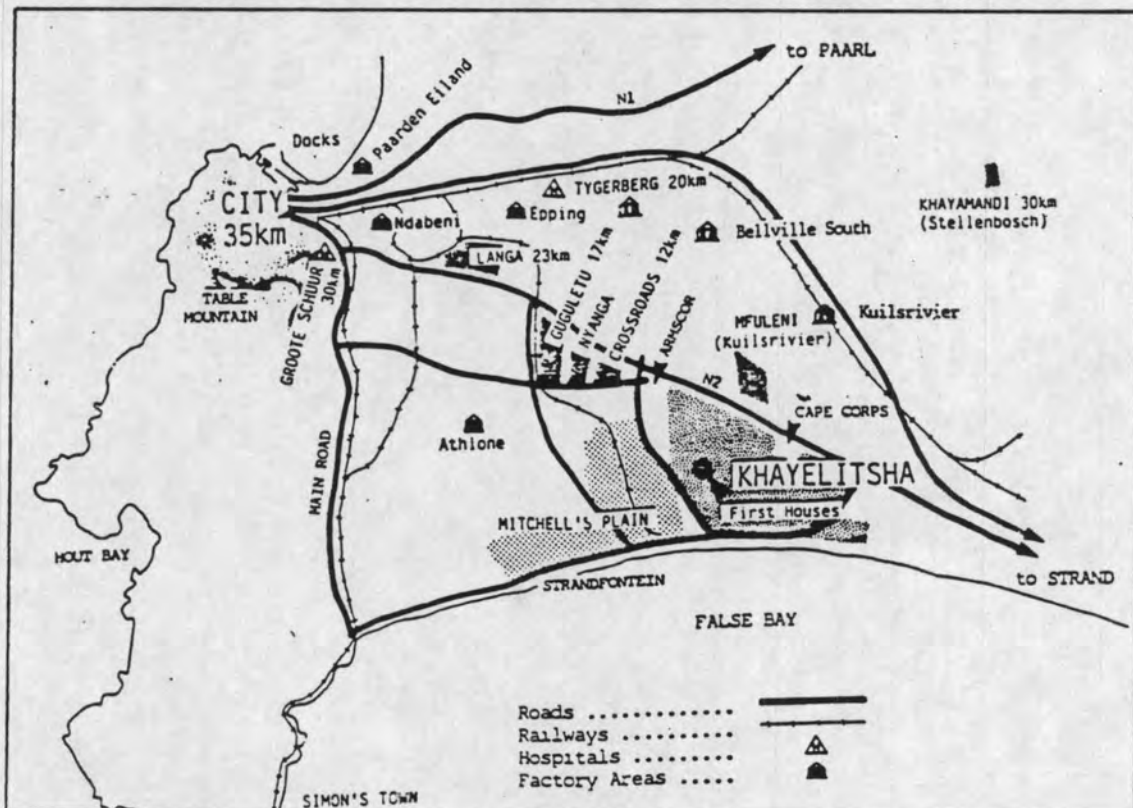
The objective of this section is to present and analyse the socio-economic data of the follow-up survey in the Transvaal and the Cape. The data has been disaggregated into the preliminary groups of old-formal, new-formal, old-informal and new-informal areas but the analysis covers first the whole sample before dealing with the abovementioned groups. It should be borne in mind that the Transvaal survey considered a single settlement that is the quintessential 'new-informal' area but for purposes of the analysis it is listed separately.

#### 5.2 A NOTE ON THE AREAS

##### 5.2.1 The "old-formal" areas

These areas consist of the townships of Langa, Gugulethu and Nyanga which are within 10km of the Cape Town CBD. These are indicated on figure 5.1, along with the other areas dealt with below.

FIGURE 5.1 BLACK RESIDENTIAL AREAS OF THE CAPE PENINSULA



Langa, the oldest remaining black township, was established in 1918. The official population was 23 000 in 1985 (Central Statistical Services report 02-85-01.) This was less than the unofficial 1959 figure (Wilson & Mafeje 1963:4). The township houses a number of large hostels and the dwellings are brick with asbestos roofs. Gugulethu and Nyanga are later creations and together had an official population of 148 000. There are a small number of flats. The majority of the dwellings are brick with asbestos roofs. In Gugulethu some upgrading is occurring and the sale of dwellings to occupants is underway. In all 3 townships the vast majority of the dwellings are still rented. There are schools, shops and a number of services, including electricity, in all these townships. The original dwellings did not have electricity but some of the new houses are supplied.

#### 5.2.2 The "new-formal" areas

These are New Crossroads and "Khayelitsha village", the latter also known as Kulani Park, and the site-and-service section of Site B. These areas are situated some 15 to 20 kilometres from the Cape Town CBD. All are recent creations - post 1982, and are reported in the 1985 census to have a population of 3500. The dwellings are brick with tile or asbestos roofs and have been erected by private contractors, often specifically for sale. The 17 schools, hospital and formal shopping centres serve both these areas and the informal areas. The whole of Khayelitsha is nominally an independent local authority.

#### 5.2.3 The "old-informal" areas

These are portions of Site B and Site C of Khayelitsha and Old Crossroads. The unofficial estimate (Black Sash, 1988) for these areas is Site C 40 000 and Site B 100 000 (part of which is formal). Some 50 000 shackdwellers were displaced by the burning of Crossroads in May 1986 and many now reside in Sites B and C. The dwellings consist almost exclusively of corrugated iron on wooden frames. The sites are unplanned and tiny, about 75 square metres, on which a site rental is levied. Services in the form of taps and latrines vary in distribution, some areas having taps every few dwellings while others have them every "block". In portions of these areas straight roads have been kept open and some are surfaced.

#### 5.2.4 The "new-informal" areas

These are the emergency camps and the areas where uncontrolled squatting occurs. Some of the areas have names such as "Greenpoint" and "Lusaka". Other areas are identified by codenumbers only, such as the MH area. The unofficial (Black Sash, 1988) population of "Greenpoint" was 20 000 at that date. The dwellings are corrugated iron and a percentage are "temporary" shelters of builders plastic ("Black City"). No services or formal roads exist in most of these areas.

The total official black population (Central Statistical Services, 1985) of Cape Town was 245 000 in 1985, with only a portion of Nyanga being 'informal'. In February 1988 the unofficial estimate (Black Sash, 1988) was 200 000 for Khayelitsha alone (both formal and informal). Such are the dimensions of rapid urbanization and census underreporting.

### 5.3 AGE AND SEX

The table below summarises the age of the respondents, sex of the respondents and the sex of the household head. No age data was collected for the Transvaal.

TABLE 5.1: FOLLOW UP SURVEY 1988/9 - AGE AND SEX VARIABLES.

AREA	SAMPLE SIZE	AV AGE RESP.	SEX RESP.		SEX HEAD/H	
			%M	%F	%M	%F
ALL CAPE	179	35,6	34,5	65,5	58,1	41,9
OLD-FORMAL	57	42,1	31,6	68,4	50,9	49,1
NEW-FORMAL	40	35,3	36,8	63,2	62,5	37,5
OLD-INFORMAL	48	32,7	25,0	75,0	64,6	35,4
NEW-INFORMAL	34	29,2	41,2	58,8	55,9	44,1
TRANSVAAL	67	-	82,5	17,5	82,5	17,5

It can be seen that the average age of respondents indicated in column 2 is ranked in declining order. This is indicative of younger populations in the informal areas which have a different function to the old formal area, as set out in more detail below.

The respondents are predominantly female, and the ratios diverge between, particularly, new and old informal areas. This may not be statistically significant as female respondents were preponderant as they were involved in domestic fuel using activities such as cooking. There is a large difference between the sex ratios of the Cape and Transvaal surveys, due to the large predominance of men in the latter survey area.

Of more significance is the sex of the household head. There are very high ratios of female heads of households and marked differences between the areas. The lower ratios in the old-formal areas indicate the relative stability of these areas. The high ratios in the remaining areas are indicative of social upheaval on an unprecedented scale. There has in fact been a fundamental change in the Cape Peninsula in the percentage of female



corroborated the Transvaal finding, with an average of 3,8 years of schooling with a standard deviation of 1,1. The lack of data on this aspect in the formal areas is an omission that should be rectified in future surveys. The BMR (BMR 130.14) indicates some 58% of the sample has less than standard 6 which corroborates the above.

### 5.5 MEASURES OF URBANIZATION AND MOBILITY

The survey attempted to ascertain the residential mobility of respondents in terms of how long they had resided at their present address and where the previous address had been. The process of urbanization is measured over time, somewhat inexactly, by the length of time since leaving the respondents 'origin'. In addition the location of this origin and the reasons for leaving were ascertained and are reported below.

TABLE 5.3: FOLLOW UP SURVEY 1988/9 MOBILITY AND URBANIZATION

AREA	YRS AT ADDRESS	PREVIOUS ADDRESS	YRS URBANIZED	MAJOR REASON			ORIGIN		
				born %	work %	fam %	Tkei %	WC %	Ci %
ALL CAPE	5,9		16,3						
OLD FORMAL	13,3	80% oldf	30,7	50	22	28	33	33	19
NEW FORMAL	4,0	75% oldf 25% ocr	24,4	42	24	34	73	9	8
OLD INFORMAL	2,5	29% ocr	8,3	7	48	45	85		8
NEW INFORMAL	0,9	62% oldf 31% sitec	9,1	41	24	35	73	10	15
TRANSVAAL	1,1	85% Tok	15,0	-	80	20	see 2 below		

- NOTE 1. Abbreviations; oldf - old formal areas, sitec - Khyalitsha, ocr - Old Cross Roads, Tkei - Transkei, WC - Western Cape Ci - Ciskei & Eastern Cape, Tok - Thokoza & Natalspruit.  
 2. Transvaal Origins - 28% Transkei, 23% Lebowa, Kangwane, Kwandebele, Gazankulu; 21% Transvaal rural, 14% Rand townships, 14% Kwazulu.

This table indicates the fundamental differences between the formal and informal areas in terms of their function within the urbanization process and within the urban economy. The formal areas, both old and new, are the residential areas of households that have been urbanized for at least one generation. The mobility within the old-formal areas is low, with the mean time at the existing address being more than 13 years. Between 75% and 80% of the previous addresses were in these formal areas, corroborating the above and also the lack of alternative accommodation in these areas.

The informal areas are the catchment areas of both the rural-urban migrants, as evinced by the average time urbanized of between 8 and 9 years, and the

household heads, from 1970 when the figure was 15% to 1985 when it was 38%, as reported in BMR 130.14. At the rate of change reported between 1975 and 1985 (1,6% pa) an average female househead ratio of 44% could be expected. The BMR report did however not cover the new-informal areas, nor, apparently, backyard shacks, both of which skew the follow up survey towards female heads of household and thus the ratios given in the table are probably representative. With regard to the Transvaal the very high ratio of male heads indicate that the "squatter" camp surveyed has a different function to those in the Cape.

#### 5.4 FAMILY SIZE, ADULT RATIO & EDUCATION

The table below summarises the data for family sizes and composition.

TABLE 5.2: FOLLOW UP SURVEY 1988/9 - HOUSEHOLD SIZE AND NUMBER OF ADULTS

AREA	AV H/H SIZE	ADULTS PER H/H	RATIO ADULT/CHILD *
ALL CAPE	5,48	3,15	1,4
OLD FORMAL	6,89	4,04	1,4
NEW FORMAL	5,23	2,82	1,2
OLD INFORMAL	5,35	3,08	1,4
NEW INFORMAL	3,62	2,15	1,5
TRANSVAAL	4,18	2,27	1,2

\* "Children" includes teenagers younger than 18 years of age.

In this table (as with age in the previous table) there is a rapid decline of household sizes from the old formal areas down. The similarity of the ratio of adults to children indicates that it is household size rather than household composition that changes from area to area. The differences in household size reveal the differences in function of the areas, with the new formal areas being the catchment areas for younger, smaller households often with single female adults. The table also reveals the multi-household use of dwellings in the old formal areas where space is at a premium.

The BMR (BMR 130.14) figure for household size is 6,37 for 1985. The inclusion of the informal areas with smaller household sizes is the probable reason for the difference between this figure and the Cape overall average household size of 5,48 in the follow-up survey.

The initial interviews of the Transvaal surveys indicated little or no formal education and a resistance to answering questions on this subject, probably due to the social stigma of illiteracy, and the questions were dropped. A sample of 39 interviews in the informal areas of the Cape was carried out and

"overflow" population of the formal areas, as evinced by the high proportion of those in the new-informal areas born in the Western Cape and moving from the formal areas. The largest percentage of "direct" migrants, those at their first address, are in the old informal areas, about 10%, rather than the new informal areas. The destruction of Old Crossroads in 1984 resulted in mass movement to the new formal areas, such as New Crossroads, and the new informal areas such as Khyalitsa Site C.

When taken over the whole survey, the Transvaal has some 30% of the sample urbanized for less than 5 years, while in the Cape this group accounts for 24% of the sample. The course of urbanization in the formal areas of the Cape is indicated in the frequency histogram, figure 5.2a. Over 60% of the sample population left their origin over 25 years ago, indicating an urbanized population in these areas. There is huge difference between the 35-40 and 30-35 year periods. The latter time period coincides with the promulgation of the Cape Labour Preference Area legislation and the expulsion of many families between 1954 and 1958. The frequency histogram of the informal areas, figure 5.2b, is in direct contrast to the formal areas. Here the populations are newly urbanised. Nearly 50% of the new informal area sample has arrived within 5 years, 90% within 15 years. The old informal areas follow a similar pattern.

The majority of those not born in the Western Cape, the first generation migrants, give the major reason for migrating as family reasons. Joining a spouse and marriage is a more common reason than work with women. In the Transvaal survey, where men are in the great majority, work is the major reason.

As to be expected the origin of new urbanites in the Western Cape is predominantly the Transkei. Less expected is that the Transkei is also a major source of the households interviewed in the Transvaal, some 28% of the total. The rural areas are an important origin in the Transvaal.

The residential mobility of a household, the number of years at the present address, as will be seen below, is a variable that is highly correlated to other socio-economic characteristics. Depending on the direction of causality it could be treated as a measure of relative social stability in the formal areas. In the informal areas however moving more often is related to a higher level of household welfare, possibly because as household circumstances improve households tend to move.



FIGURE 5.2a. TIME URBANIZED  
FORMAL AREAS

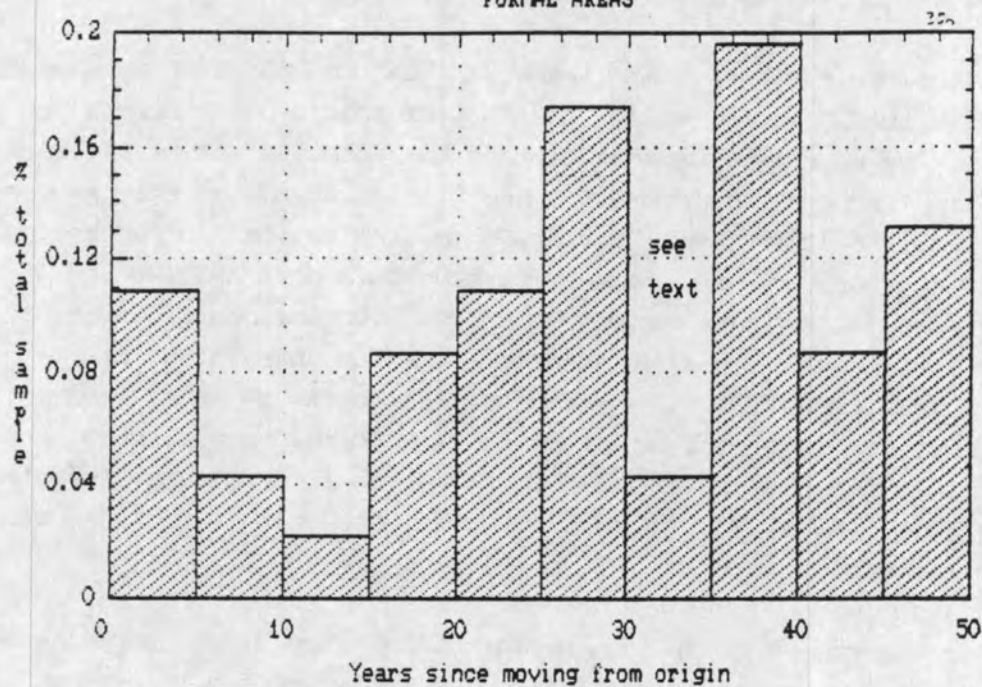
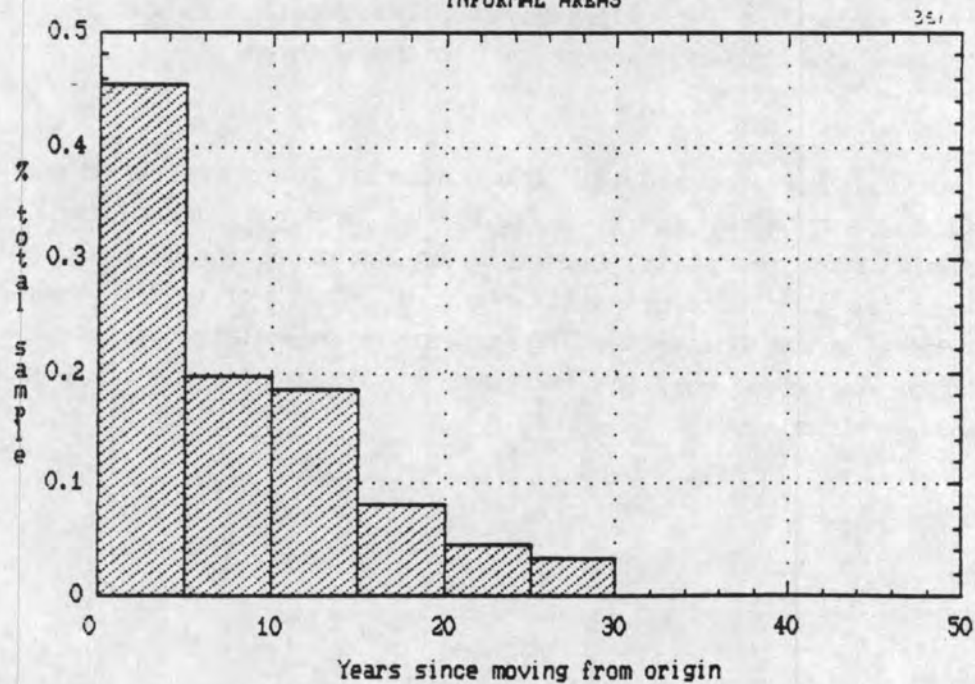


FIGURE 5.2b TIME URBANIZED  
INFORMAL AREAS





## 5.6 INCOME, EMPLOYMENT & EXPENDITURE

Income data was collected in categories (see questionnaire Appendix 2) as the initial few interviews in the Transvaal uncovered resistance to answering direct questions on income. No attempt was made to disaggregate income by source. The number of employees per family and the type of employment was recorded. Large ranges of incomes were found and the large standard deviations of these data make the use of frequency measures as analytical tools preferable to measures of central tendency. The income and employment variables are tabulated below.

TABLE 5.4: FOLLOW UP SURVEY 1988/9 - INCOME AND EMPLOYMENT VARIABLES

AREAS	MEAN INC/WK H/H	MEAN INC/WK PER PERS	NO EMPLOY/ H/H	EMPLOYMENT TYPE				
				UN %	P %	SF %	F %	S %
ALL CAPE	145,01	37,16	1,77					
OLD FORMAL	170,31	36,78	1,78	4	9	9	16	62
NEW FORMAL	158,05	40,59	1,71	0	3	12	21	64
OLD INFORMAL	137,27	34,26	1,78	0	0	25	31	44
NEW INFORMAL	100,16	38,07	1,82	3	0	15	41	41
TRANSVAAL	208,95		1,18	8	0	21	60	10

ABBREVIATIONS. INC/WK - income per week; H/H Household;  
UN - unemployed; P Pensioner; SF self employed;  
F Industry; S Services, including retail and domestic

In continuance of the emerging pattern described in the sections above the income per household per week declines from the old-formal area down. This decline is offset by the fall in mean family sizes and in the case of the new-informal areas further offset by the increased ratio of employees per family. The Transvaal diverges from the pattern by having a markedly higher income and markedly lower employee ratio. The frequency histograms of the Cape sample as a whole and the Transvaal are indicated in figures 5.3a & 5.3b.

The income figure of the BMR for the Western Cape was R125 per household in 1985 (BMR 130.14). Figure 5.3c indicates the frequency distributions of both the follow-up survey and the BMR data (not adjusted for inflation), with the data aggregated as per the BMR income groupings. The figure indicates that the income distribution of the BMR is higher than the follow-up survey in the 5 highest income groups.

FIGURE 5.3a INCOME DISTRIBUTION  
FOLLOW-UP SURVEY (CAPE): 1988/9

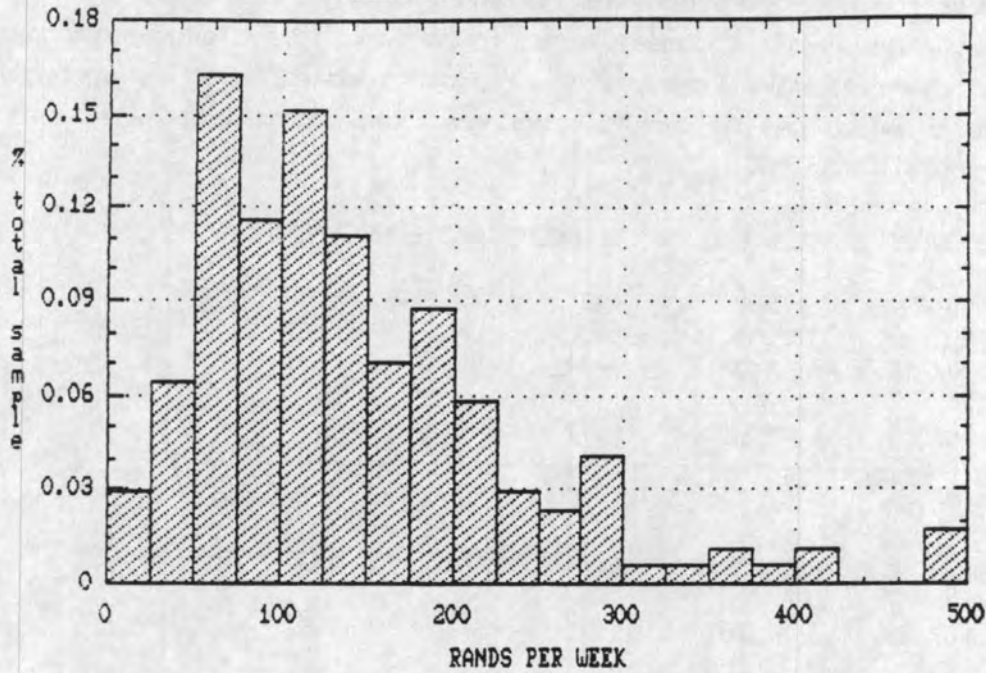


FIGURE 5.3b. INCOME DISTRIBUTION  
TRANSVAAL SURVEY: 1988

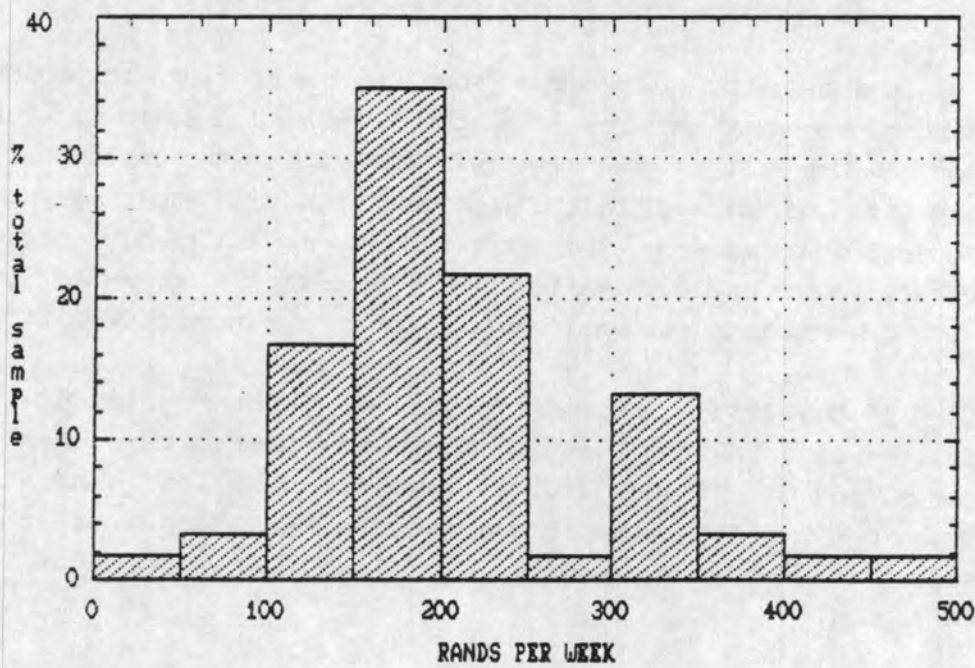
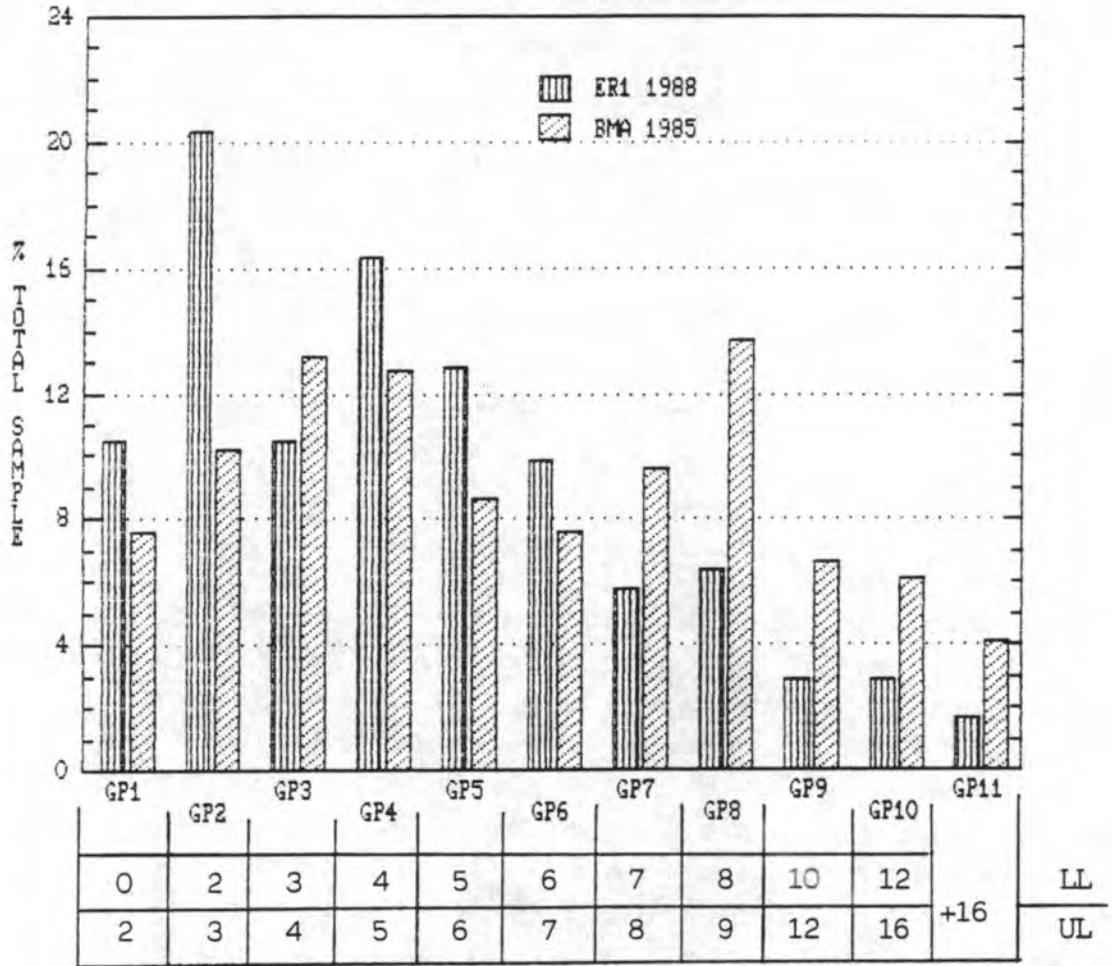


FIGURE 5.3: COMPARISON OF HOUSEHOLD INCOME  
ERI 1988 SURVEY & BMA 1985 SURVEY



LL - Lower limit UL - Upper limit Thousands of Rand (1985) p.a.

The survey found the number of earners per household to be 1,39. This figure is a substantial drop from the BMR figure of 1,52 in 1975. The reasons for this drop are probably the increasing number of unemployed and self-employed that do not fit into the category earner. This difference in definition is also the probable reason for the divergence of the figure in the table above from the BMR figure.

The percentage figures on employment type should be treated with some caution as the stigma attached to being unemployed leads to under-enumeration of this figure. Similarly the category self-employed disguises underemployment. Notwithstanding the above a clear trend in the increased importance of self-employment and employment in industry in the informal areas is evident.

Data on expenditure in three categories was collected. These are expenditure on food, expenditure on clothing and all expenditure, each given or transformed as a figure per week. Only total expenditure data was collected for the Transvaal.

TABLE 5.5: FOLLOW-UP SURVEY 1988/9 - EXPENDITURE VARIABLES

AREAS	FOOD EX WEEK H/H	CLOTH EX WEEK H/H	ALL EX WEEK H/H	EXP/INC RATIO	BASIC RATIO	CAR/ H/H
ALL CAPE	R61,42	R13,55	R113,55	0,78	0,66	0,20
OLD FORMAL	90,72	23,05	170,34	1,00	0,67	0,32
NEW FORMAL	77,98	14,66	115,21	0,73	0,80	0,23
OLD INFORMAL	31,82	8,03	53,38	0,39	0,74	0,08
NEW INFORMAL	32,89	6,19	37,69	0,38	1,03	0,16
TRANSVAAL	-	-	42,69	-	-	0,25

NOTE. 1. EXP/INC RATIO = total H/H expenditure / income H/H  
 2. BASIC RATIO = Food + clothing expenditure / total H/H expenditure.

This table shows that the food, clothing and all expenditure are ranked in decreasing order as with the other tables above. The expenditure on basics, food and clothing, tends towards the reported total expenditure in the informal areas (indicating the problem with quantifying irregular purchases such as clothing). This is in line with expectations but also suggests that the data in these areas could be unreliable. The ratio of basic expenditure to total household expenditure increases in the informal areas, indicating decreasing discretionary expenditure for non-basic purchases. However the ratio of total household expenditure to household income indicates an increase in discretionary income in the formal areas. If the data are reliable these seemingly contradictory results can only be reconciled by postulating that households in the informal areas spend largely on basics only and save, remit, or repay most of the household income.

The budget shares of food and clothing are higher than the BMR figures for 1985 (BMR 130.14). The share of food for the Cape as a whole is 54% compared to 36% for the BMR. Clothing is 12% as opposed to 8% (down from 15% in 1975) given by the BMR. This is probably due to the lower income of the sample population. The car ownership ratio given in the last column is an excellent surrogate of 'wealth' and is in keeping with the above findings.

## 5.7 THE BUILT ENVIRONMENT

The access to services is governed by the location of a household. The built environment also sets rigid limits on floorspace. The fundamental difference in comfort and security between the brick walled, asbestos roofed dwellings of the formal areas and the wood, corrugated iron and plastic shacks of the informal areas need not be tabulated to be appreciated. It is the essence of the categorisation used throughout. Some statistics on the number of buildings, rooms and occupancy are however of interest and are tabulated below.



TABLE 5.6: FOLLOW-UP SURVEY 1988/9 - HOUSING VARIABLES

AREAS	BUILD/ SITE	SHACKS/ SITE*	ROOMS/ BUILDING	PERSONS/ ROOM
ALL CAPE	1,6	0,6	2,9	2,1
OLD FORMAL	2,4	1,3	3,5	2,1
NEW FORMAL	1,6	0,5	1,1	2,4
OLD INFORMAL	1,1	all	3,2	1,8
NEW INFORMAL	1,0	all	2,0	2,1
TRANSVAAL	1,1	all	2,6	1,7

\*Shacks are 'backyard' structures in formal areas. Average number over whole sample.

Growth by accretion in the form of adding on rooms and backyard shacks has led to the high figures of buildings and shacks per site in the old formal area. This response has however reduced the overcrowding in these areas to below that of the new formal areas where the small conventional houses have few rooms. It is noteworthy that the old informal areas are the least crowded in terms of occupancy per room.

## 5.8 SOME CORRELATIONS BETWEEN THE SOCIO-ECONOMIC VARIABLES

The relationships between the numeric socio-economic variables were explored for both the Cape and Transvaal. The correlation matrices are tabulated in table 5.7 below.

There are correlations between many of the variables in the Cape, indicating that multicollinearity is a major problem, in keeping with other energy studies. This means that the variables are not independent. A parametric partial correlation analysis was conducted to verify the results as this technique measures between two variables while removing the linear relationships with other variables, noting however that the relationships are largely curvilinear. There was broad agreement between the two techniques and the results are as follows:-

- 1) In the Cape the age of the respondent is strongly correlated with time since leaving place of origin (years urbanized). This is in agreement with the findings of Kok (1984) that rural-urban migration is predominantly by the young.

TABLE 5.7 CORRELATION MATRIX: SOCIO-ECONOMIC VARIABLES:  
SPEARMAN RANK CORRELATION COEFFICIENTS

A. CAPE

VARIABLE	CODE	A	B	C	D	E	F	G	H	I
Age Respondent	A	1								
Yrs at Address	B	,40	1							
Yrs Urbanized	C	<b>,63</b>	<b>,59</b>	1						
H/H size	D	,27	<b>,48</b>	,29	1					
No Adults H/H	E	,19	<b>,44</b>	,26	<b>,64</b>	1				
No Employed H/H	F	-	-	-	,26	,39	1			
Income	G	-	,24	-	,19	,31	<b>,47</b>	1		
Expenditure	H	,22	,37	,25	,30	,31	-	,31	1	
No Builds/site	I	,22	,33	,26	,31	,29	-	,11	<b>,44</b>	1

B. TRANSVAAL

VARIABLE	CODE	A	B	C	D	E	F	G	H	I
Age Respondent	A	nc								
Yrs at Address	B	nc	1							
Yrs Urbanized	C	nc	,26	1						
H/H size	D	nc	-	,37	1					
No Adults H/H	E	nc	-	-	<b>,44</b>	1				
No Employed H/H	F	nc	-	-	-	-	1			
Income	G	nc	-	-	-	-	,38	1		
Expenditure	H	nc	-	-	-	-	,34	<b>,44</b>	1	
No Builds/site	I	nc	-	-	-	-	-	-	,31	1

nc - not collected.

Levels of significance all 95% or greater.

2) In the Cape the length of time at the present address (residential mobility) is the most strongly correlated variable as indicated by the coefficients in bold above. In the partial correlation analysis there are positive correlations to adults per family, years urbanized, food and clothing expenditures, and number of rooms. It also had negative correlations with the number of employees per family, income and total expenditure. There are thus conflicting interpretations of the effect of this mobility variable.

3) In the Cape the number of employees per household was not correlated to any other variable as indicated above. However the partial correlation analysis indicates a positive correlation to the number of adults per family and food and clothing expenditure and negatively to total expenditure and buildings per site.

4) In the Cape income is only well correlated with the number of employed. It is noteworthy that there is not the expected close relationship between income and expenditure. The partial correlation analysis however indicates that in both the Cape and Transvaal income is

correlated with the expenditure variables (food, clothing, total) and the number adults and employees.

In the light of the above, five major variables can be extracted with the intention of reducing the effect of multicollinearity. These major variables are, time from origin, family size, income, total household expenditure and number of buildings per site. Four of these have low cross-correlations but total household expenditure has higher correlations. It is included due to its importance. The correlation matrix is tabulated below:-

TABLE 5.8 CORRELATION MATRIX. PARTIAL CORRELATION COEFFICIENTS AND SPEARMAN CORRELATION COEFFICIENTS. CAPE

		Time Away	H/H size	Income	All Expend	Bld/site
Time away	PCC	1,0	,32	-,18	,22	,20
	SOC		,29	-	,25	,25
H/H size	PCC		1,0	,19	-	,10
	SOC			,19	,30	,31
Income	PCC			1,0	,67	,21
	SOC				,31	,11
Total Expend	PCC				1,0	-,17
	SOC					,44
Buildings/site						1,0

PCC - Partial Corr Coeffs      SOC - Spearman Corr Coeffs

As can be seen appreciable collinearity still exists. A principal component analysis of the 12 socio-economic variables indicate that the abovementioned 4 variables can explain 69% of the variation.

It should be noted that the picture is more complex once the whole sample is broken down into areas. The variables have widely different correlations from area to area, particularly time away from origin and income. The differences between the Cape and Transvaal are immediately apparent from table 5.7, although some of this can be explained by the difference in sample sizes.

## 5.9 CONCLUSIONS

It is apparent from the data presented that there are wide differences in the socio-demographic and socio-economic characteristics of the sample population. Considering the sample as a whole, no single variable influences these differences as much as the type of dwelling of a household. This is a spatial variable as much as an environmental one as the location of a dwelling governs access to employment and services, of which electricity is one. As a result a primary categorisation into formal and informal, and the old and new components of these categories, has been made.

The socio-economic data collected indicates significant differences in family size, average age, income, expenditure and employment, and in fact in all the variables listed, between the four categories of areas (and also the Transvaal). In terms of urbanization and the urban economy the areas have different functions. The informal areas are acting as the overflow for the growth and family formation of the black population of Greater Cape Town. In addition the "influx" of migrants from rural areas is to these informal areas. The evidence relating to poverty is somewhat contradictory. The household incomes are lower in the informal areas but the per capita incomes are similar to their formal counterparts. In the informal areas the ratio of expenditure on food and clothing to total household expenditure is higher, and car ownership per household is lower - both indicative of a higher degree of poverty in these areas. Paradoxically, discretionary income per household appears to be higher in the informal areas. This also calls the reliability of the income and expenditure data into question.

These differences are vital in the search for clues to the energy transition process as they allow cross-sectional comparisons between different groups of the sample population to be made. However, a correlation analysis of socio-economic variables indicates that multi-collinearity is a major problem as each of the variables is dependent on the others to some extent. To reduce this problem four major variables are chosen that have reasonably low collinearity. Total household expenditure is included of necessity.



## CHAPTER 6

### ANALYSIS OF THE FOLLOW-UP SURVEY PART 2 - FUEL RELATED DATA

#### 6.1 OBJECTIVES

In this section the data relating to fuels and energy in the follow-up survey are analysed. The disaggregation of the Cape sample into areas is as before. Throughout this section the common measure of central tendency, the mean (or average), is tabulated and discussed. The reader is reminded that the data has large ranges on either side of this mean and that the mean itself has varying degrees of accuracy, all of which are discussed in Appendix 4.

At this level of analysis cross-sectional indications of the energy transition begin to be revealed through differences in fuel expenditure and consumption patterns in the subgroups of the sample population.

#### 6.2 FUEL USE BY HOUSEHOLD

There is a small difference between the number of households reported purchasing fuels and the number using fuels. This is due to incomplete data collection rather than the non-commercial nature of some fuels. The reported purchase of fuels by households in percentage terms is tabulated below.

TABLE 6.1 INCIDENCE OF FUEL USE: % OF HOUSEHOLDS PURCHASING FUELS.

AREA	CANDLE %	DRYBAT %	CARBAT %	COAL %	WOOD %	PARA %	GAS %	ELEC %
ALL CAPE	37,8	50,0	22,8	0	1,7	92,2	31,7	17,8
OLD FORMAL	17,5	29,8	15,8	0	0	77,2	31,6	49,1
NEW FORMAL	50,0	55,0	37,5	0	2,5	97,5	55,0	10,0
OLD INFORMAL	55,1	77,6	22,4	0	2,0	100,0	24,5	0
NEW INFORMAL	29,4	38,2	17,6	0	3,0	100,0	17,6	0
TRANSVAAL	97,0	58,2	11,9	86,6	85,1	94,0	23,9	0

The table indicates that a complex system of interrelationships exists between the various fuels. Multiple fuel use is the rule rather than the exception. In addition the patterns of fuel use change by area. Fuel use over the whole sample and by each individual fuel group is analysed in this chapter but fuel use by multiple use group is dealt with in the next.

The table also indicates that, according to this survey, paraffin is the most ubiquitous major fuel, followed by gas in distant second place. Moreover this

is the case even in the electrified areas, but with electricity in second place. In the Cape so few households used wood that the percentages given are not considered statistically valid. What is significant is the complete absence of coal (and charcoal) use in the Cape, compared to the high usage of coal in the Transvaal.

In terms of energy transition it is apparent that a shift of population from informal to formal will increase the incidence of gas and electricity purchase and decrease that of paraffin.

### 6.3 EXPENDITURE ON FUEL

#### 6.3.1 Whole Sample Data

The mean weekly expenditures on fuels, per household, as at date of collection, for the various fuels and taken over the whole sample (sub-sample in the case of the areas) are tabulated below. It must be borne in mind that this is an aggregate measure in which the whole sample or sub-sample is the divisor and is not the actual expenditure on fuels by households.

TABLE 6.2: MEAN WEEKLY EXPENDITURE ON FUEL PER HOUSEHOLD IN RANDS.  
MEAN OF WHOLE SAMPLE & SUBSAMPLE

AREA	CAND R	DBAT R	CBAT R	CL R	WOOD R	PARA R	GAS R	ELEC R	TOT R
ALL CAPE	0,60	0,45	1,00	0	0,29	3,85	3,65	2,16	12,00
OLD FORMAL	0,34	0,32	0,79	0	0	3,13	3,47	5,95	14,00
NEW FORMAL	1,04	0,65	2,09	0	0,15	3,59	7,83	1,26	16,61
OLD INFORM	0,64	0,47	0,71	0	0,34	5,32	2,07	0	9,55
NEW INFORM	0,47	0,38	0,80	0	0,88	3,28	1,31	0	7,12
TRANSVAAL	1,70	0,95	0,45	9,13	1,33	2,50	2,00	0	18,06

From this table some tentative conclusions can be drawn. The greater usage of gas and the use of electricity leads to higher total fuel expenditures in the formal areas. These two fuels together make up 67% and 55% of the total fuel budgets in the old formal and new formal areas respectively.

There is a absolute decline in the expenditure on all fuels, except paraffin, between the formal and informal categories. In the poorer informal areas paraffin accounts for 56% and 46% of the total fuel budget in the old and new informal areas respectively. Again, the numbers using wood are so small the amounts are not representative.

The Transvaal represents a different system, based on coal which accounts for half of the total energy cost there. The total fuel cost is much higher than in the new informal areas of the Western Cape.

The influence of family size and income is indicated in the following summary table.

TABLE 6.3 FUEL EXPENDITURE PER CAPITA & SHARE OF INCOME/EXPENDITURE

AREA	FUEL EXP PER CAP R/WEEK	% H/H INC	%H/H EXPEND
ALL CAPE	2,19	8,3	10,6
OLD FORMAL	2,03	8,2	8,2
NEW FORMAL	3,17	10,5	6,9
OLD INFORMAL	1,78	7,0	17,8
NEW INFORMAL	1,97	7,1	18,9
TRANSSAAL	4,32	8,6	22,3

This reveals that the largest portion of income is spent on fuels in the new formal areas. In the remaining areas the proportion is within the narrow band of 8,6% to 7,0%, with the Cape informal areas actually having a lower proportion than the formal areas. This finding, while indicating a consistent place in the household budget for energy, must be treated with circumspection as the range of incomes is wide. The share of fuel of total household expenditure indicates the opposite relationship, with the informal areas having a much higher figure.

In terms of mean fuel expenditure per capita the Transvaal is more than double that of its Cape informal counterparts. This is accounted for in part by the fact that the Transvaal survey was in winter with coal use at a peak. In the Cape the lowest expenditure per capita is in the old informal areas which is some 40% lower than the new formal areas. Table 6.2 reveals that this was the result of the use of gas and electricity.

#### 6.3.2 Fuel Group Data

All the above are aggregate expenditures over the samples and sub-samples in question. When calculated within each user group the average expenditures of users in that group rises significantly. This effect is the result of the exclusion of households not using a particular fuel and gives an indication of the actual mean weekly expenditures of those using that fuel. Both methods of calculation are used throughout this chapter.

TABLE 6.4: MEAN WEEKLY FUEL EXPENDITURE PER HOUSEHOLD  
FOR HOUSEHOLDS USING FUEL

AREA	CAND GROUP	DBAT GROUP	CBAT GROUP	COAL GROUP	WOOD GROUP	PARA GROUP	GAS GROUP	ELEC GROUP
ALL CAPE	1,59	0,90	5,00	0	17,68*	4,17	11,65	12,18
OLD FORMAL	1,95	1,09	6,10	0	0	4,05	11,64	12,12
NEW FORMAL	2,06	1,20	5,58	0	6,25	3,68	14,24	12,59
OLD INFORMAL	1,15	0,61	4,37	0	nr	5,32	8,46	0
NEW INFORMAL	1,62	0,99	5,50	0	nr	5,66	7,92	0
TRANSVAAL	1,74	2,30	3,75	10,71	1,54	2,65	8,36	0

\* includes nr below.

nr = not representative. Wood use not domestic. see section 7.7.1 below.

Cbat = car battery users. Expenditure is based on number of charges/week.

The table indicates that the mean weekly expenditures of gas and electricity users are in the order of 3 times those of paraffin users in the formal areas. In the informal areas gas users pay on average 40% to 60% more than the paraffin users. As suggested above the Transvaal is a different system to the Cape with coal being the dominant fuel. Even so, in the Transvaal gas users pay over 3 times as much for their fuel than paraffin users do. There is however multiple use of fuels in the great majority of households in both regions and thus the final picture in terms of proportionate fuel cost is more complex.

The energy transition process is again revealed by the differences in expenditure on paraffin, gas and electricity. It appears that the budget share of expenditure rather than share of income is a measure of the level of the process as large differences in the former share occur between formal and informal areas.

For those using them dry batteries and car batteries constitute significant expenditures. These fuels are not easily substitutable in the non-electrified informal areas. Due to the specialised nature of their application they do not play a major role in the domestic energy transition process.

#### 6.4 QUANTITIES OF FUEL USED

The various fuels used are tabulated below, each in the common units in which they are purchased. The table is for the whole sample, or sub-sample, and thus includes non-users of each fuel. Electricity is not included as it is purchased in Kwh and energy units are dealt with in the following section. Dry batteries of many different sizes are used and in pure number terms are not comparable and are hence not included.



TABLE 6.5 MEAN WEEKLY QUANTITIES OF FUEL USED PER HOUSEHOLD  
MEAN OF WHOLE SAMPLE & SUBSAMPLE

AREA	CAND No	CARBAT No	COAL Kg	WOOD Kg	PARA Litr	GAS Kg
ALL CAPE	3,3	0,25	0	-	6,43	3,07
OLD FORMAL	2,0	0,19	0	-	5,19	3,22
NEW FORMAL	6,2	0,38	0	-	6,22	6,07
OLD INFORMAL	3,2	0,24	0	-	8,56	1,72
NEW INFORMAL	2,3	0,17	0	-	5,66	1,23
TRANSVAAL	8,4	0,19	40,67	14,57	3,67	1,00

Mass of wood not representative in Cape

Assume 25kg coalbag

Assume 10kg woodbundle

The old informal areas emerge as the biggest volumetric consumers of paraffin. The low figure for paraffin in the new informal areas is due to the household size effect. The table reveals that it is the new formal areas where gas use predominates.

When calculated in terms of each user group where only those using the fuels are considered a different pattern emerges.

TABLE 6.6 MEAN WEEKLY QUANTITIES OF FUEL USED PER HOUSEHOLD  
HOUSEHOLDS USING FUEL

AREA	CAND GROUP	CARBAT GROUP		COAL GROUP	WOOD GROUP	PARA GROUP	GAS GROUP
	No	No	CH*	Kg	Kg	Litr	Kg
ALL CAPE	8,8	1,1	2,1	0	-	6,97	9,52
OLD FORMAL	11,4	1,2	2,0	0	-	6,73	10,21
NEW FORMAL	12,4	1,0	2,2	0	-	6,38	11,05
OLD INFORMAL	5,9	1,1	1,75	0	-	8,56	6,94
NEW INFORMAL	7,3	1,0	2,2	0	-	5,65	6,96
TRANSVAAL	8,76	1,6	1,5	40,67	14,57	3,91	4,18

\*Number of charges per battery per week.

It is noteworthy that in the table above the usage of paraffin differs markedly in the two areas where paraffin is the most ubiquitous, the old and new informal areas, while the use of other fuels is similar. This is again

due to the larger household size in the former area. Gas usage per household is markedly similar in the two formal areas on the one hand and the two informal areas on the other. This suggests that an environmental variable may play a role.

The following table calculates fuel usage, within each user group, on a per capita basis. This removes the influence of household size.

TABLE 6.7 MEAN WEEKLY QUANTITIES OF FUEL USED PER CAPITA  
HOUSEHOLDS USING FUEL

AREA	CANDLES GROUP no	PARAFFIN GROUP litre	GAS GROUP kg
ALL CAPE	1,61	1,27	1,74
OLD FORMAL	1,65	0,98	1,48
NEW FORMAL	2,37	1,22	2,10
OLD INFORMAL	1,10	1,60	1,30
NEW INFORMAL	2,02	1,56	1,92
TRANSVAAL	0,35	0,94	1,00

The summary table above indicates that on a per capita basis paraffin has indeed a greater use in the informal areas. On this basis however more gas is used in the new formal areas than in the older more established townships, and even more than in the old formal areas. The pattern of use of candles cannot be explained at this stage.

## 6.5 ENERGY CONSUMPTION

The different energy content of the various fuels used in the domestic sector results in differing nett energy consumption which is the potential energy output ignoring any losses. To calculate these nett figures the following conversion factors were used:-

### Energy Output

Coal - 27 MJ/kg

Paraffin - 37 MJ/kg

Wood - 17 MJ/kg

Carbat - 0,36 Kwh per charge

Gas - 49 MJ/kg

Electricity - 3,6 MJ/Kwh - 1988 unit cost 10,22c/Kwh in townships

(Source: Eberhard, 1986)

Some of these figures differ slightly from the conversion figures used by the United Nations (1986) which are; Paraffin 43,2 MJ/kg and Gas 45,5 MJ/kg. On this basis the gross energy outputs may overstate that of wood and gas and understate paraffin.

In reality the various appliances used for different fuels have markedly different efficiencies which, when considered, result in a measure of the useful energy consumed.

These useful energy figures are calculated according to the following efficiencies:-

#### Efficiencies

Electric Stove	80%
Gas stove	75%
Paraffin stove	50%
Coal stove	20%
Wood stove	10%

(Source Eberhard, 1986)

Again some of these figures differ from other sources. Prasad et al (1983) measured the efficiency of Gas stoves at 55% and Paraffin stoves at between 54% and 57%. As a result the useful energy figures cited herein may again overstate the contribution of gas and understate that of paraffin.

Useful energy consumption figures are given below and shown in percentage terms in figure 6.1. Candles, dry batteries and car batteries deliver tiny (although useful) amounts of energy which are not considered below.

TABLE 6.8 USEFUL ENERGY CONSUMPTION PER WEEK PER HOUSEHOLD MEGAJOULES  
WHOLE SAMPLE

AREA	COAL	WOOD	PARA	GAS	ELEC	TOTAL
ALL CAPE	0	9,4	118,9	112,7	76,2	317,2
OLD FORMAL	0	0	96,2	118,4	209,6	424,2
NEW FORMAL	0	5,3a	115,0	223,3	44,4	388,0
OLD INFORMAL	0	12,7b	158,4	62,5	0	233,6
NEW INFORMAL	0	25,0c	104,7	45,1	0	174,8
TRANSVAAL	175,7	21,4	68,0	36,7	0	301,8

NOTE. Wood - a 1 resp., b 2 reps., c 1 resp - all non-domestic users - not representative.

The figures generated above should be used with some caution as the multi-usage of fuels results in a wide range of total net energy consumed. In addition the efficiencies of the appliances have not been established under field conditions in South Africa. Even under laboratory conditions the efficiencies are subject to variation.

The figure illustrates the fundamental difference between the Cape and Transvaal with coal providing 58% of the total useful energy in the latter. In the Cape it is evident that in terms of useful energy gas is a now a major fuel.

Considering the area groups in terms of useful energy, in the old formal areas which incorporate the largest number of electricity users that fuel is dominant, followed by gas. In the new formal areas gas dominates, with paraffin second. In the informal areas paraffin emerges as the dominant fuel. There is also a increase in the total useful energy consumed by a household in the different areas - by some 144% from new informal to old formal. This is more than the maximum difference in average household expenditure on fuels between the areas which is 133%.

In terms of energy transition this is of fundamental importance as it means that a relative population shift to the formal areas is accompanied by an increase in the amount of useful energy used. This increase occurs however at same time that the budget share of fuel decreases and is relatively more than the increase in expenditure, due to reasons of increased efficiency and price differentials.

Further insight is gained by a regional and cross-country comparison of useful energy consumption in similar areas as tabulated below.

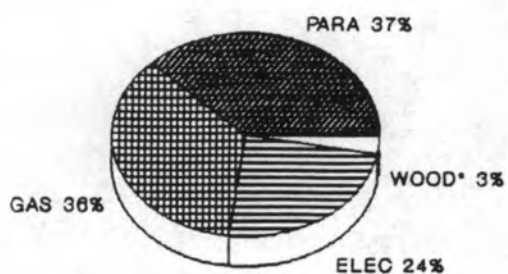
TABLE 6.9 ANNUAL USEFUL ENERGY CONSUMPTION IN INFORMAL AREAS:  
THE CAPE, TRANSVAAL AND ZIMBABWE. TJ / ANNUM PER HOUSEHOLD

FUEL	ALL CAPE	NEW INFORMAL	TRANSVAAL INFORMAL	ZIMBABWE "HIGH DENSITY"
COAL*	0	0	4,6	0,6
PARAFFIN	6,2	5,4	3,5	0,3
GAS	5,9	2,3	2,5	0
ELECTRICITY	4,0	-	-	3,1
FUELWOOD	-	-	1,1	1,0
TOTAL	16,1	7,7	11,7	5,0

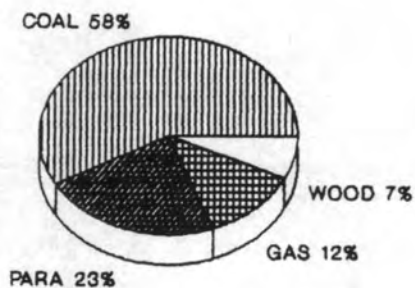
NOTE: \* assume usage of coal for 6 months per annum



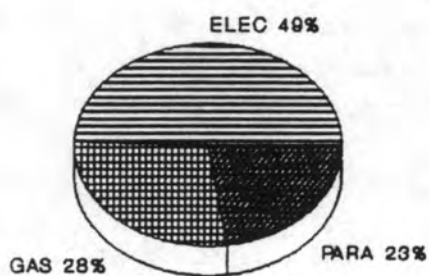
FIGURE 8.1 PERCENTAGE SHARE OF FUELS OF  
TOTAL USEFUL ENERGY CONSUMPTION



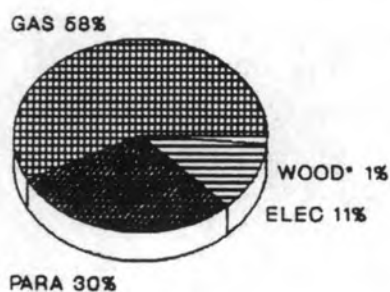
*ALL CAPE*



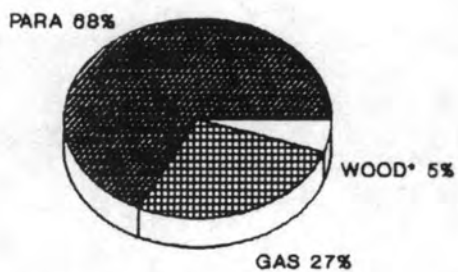
*TRANSVAAL*



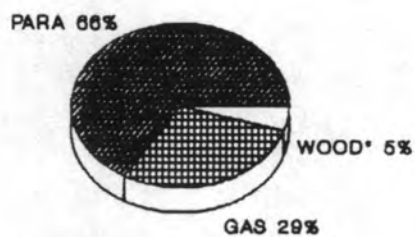
*OLD FORMAL*



*NEW FORMAL*



*OLD INFORMAL*



*NEW INFORMAL*

It is striking that electricity supplies over 60% of the useful energy in the Zimbabwean "high density" areas. The question is whether the introduction of electricity to the South African informal areas would reduce the consumption of transitional fuels. It is noteworthy that these areas have a higher total useful energy consumption without electricity at present. In addition, as indicated in table 6,8 above, gas consumption is primarily in those areas with electricity at present.

#### 6.6 AVERAGE COSTS OF FUELS AND USEFUL ENERGY COSTS

The different types of market structure in the various areas lead to different average costs, as set out in the table below. The energy costs are useful energy costs rather than nett costs prior to use and as such are corrected for the different efficiencies of appliances. Wood is not included as the samples are too small. Dry batteries, candles and car batteries are also not included as their contributions are insignificant.

In the case of average costs these appear to vary little, but again the range of values within each area is large. The cost of candles is higher in the informal areas. In the case of paraffin the variation is proportionately small, except in the Transvaal area. The average cost of gas varies most, due to the large differences in unit cost, depending on the size of gas container used.

TABLE 6.10 AVERAGE COSTS AND USEFUL ENERGY COST OF FUEL  
PER WEEK PER HOUSEHOLD - WHOLE SAMPLE

AREA	PARAFFIN		GAS		ELEC
	c/lt	c/MJ	R/kg	c/MJ	c/MJ*
ALL CAPE	60	3,2	1,19	3,6	3.5
OLD FORMAL	60	3,3	1,07	3,3	3.5
NEW FORMAL	58	3,1	1,22	3,7	3.5
OLD INFORMAL	62	3,4	1,20	3,7	-
NEW INFORMAL	58	3,1	1,06	3,3	-
TRANSSVAAL	68	3,7	1,00	3.1	-

\* Does not include service charge of R2,20/month

In the case of useful energy costs the similarity between the various fuels is striking. In the Cape as a whole paraffin is marginally cheaper than gas and electricity. If the service charge is included however gas and electricity reverse ranks. In the Transvaal gas is the cheapest, followed by paraffin and then (not tabulated) coal which is used in braziers with very low (approx 10%) efficiencies. Candles increase in costs from formal to

informal areas, as does paraffin. Gas does not share the usual pattern and is cheaper in the new informal areas.

In terms of the above it is unlikely that useful energy cost is a factor in determining the choice of fuels.

## 6.7 CONCLUSIONS

This chapter indicates the relative importance of the various fuels under consideration but also raises the question as to how these measures themselves should be ranked in importance. If ubiquity is the measure then paraffin is preeminent. In terms of useful energy consumed gas and electricity are the most important in the formal areas and paraffin in the informal areas. In the Transvaal coal replaces paraffin.

This chapter suggests that, on the basis of cross-sectional comparison, if there is a relative shift of population from informal to formal areas an energy transition process will occur with a substitution of electricity and gas for paraffin and coal. Gas appears to have a special role that allows its continued consumption in spite of the use of electricity. As suggested below the investment level in gas appliances may explain this phenomena.

At this level there is no indication as to how fuels are individually chosen. The analysis suggests that unit price on a useful basis is not a consideration as the values for all fuels are very close. Perceived price is dealt with below. On an aggregate basis however the choice of fuels and the total amounts used allow for significantly different budget shares of fuel in the formal and informal areas.



## CHAPTER 7

### INTERRELATIONSHIPS BETWEEN FUEL VARIABLES AND SOCIO-ECONOMIC VARIABLES

#### 7.1 INTRODUCTION

This chapter deals with the interrelationships of the fuel related variables with each other and with the socio-economic variables. At the outset it must be stressed that fuel usage appears to be determined by a broad range of criteria that vary with socio-economic status. In addition fuel usage varies greatly within each area and group and in keeping with other energy studies there is a large scatter of data. The primary problem is that of multicollinearity among the independent variables. As indicated in section 5.8 a preliminary remedy is the choice of major independent variables that have the lowest covariances.

As a result only certain variables were selected for investigation; namely the major socio-economic variables, and the fuel expenditure and useful energy variables. Fuel consumption is highly correlated with expenditure on fuels, as indicated below. As the latter is invariably more accurately reported, especially where fractional purchases occur, fuel expenditure is treated in more detail in this chapter.

#### 7.2 CORRELATIONS BETWEEN FUEL EXPENDITURE AND CONSUMPTION

The fuel variables are not independent. There are strong, but not perfect, positive correlations between expenditure on each fuel and the amounts of that fuel used in the Cape and Transvaal, ranging from 0,83 to 0,99 (Spearman Rank correlation coefficients at 99% significance level). These correlations are a measure of the informality of the markets for each fuel. The ascending rank order in the Cape is candles (0,88), paraffin (0,94), and gas (0,95) - which is as expected from the fuel vendor study. Candles are largely bought at local shops, as is paraffin.

In the Transvaal a different ranking prevails. The ascending rank order is wood (0,83), coal (0,87), paraffin (0,95), gas (0,97) and candles (0,99). Both wood and coal are sold door to door in the Transvaal in a highly informal market. Paraffin is sold at local shops and gas and candles purchased at formal retail outlets.

As a result of this close correlation the patterns described in detail below, with regard to the fuel expenditure variables, apply equally to the fuel (but not energy) consumption variables.



### 7.3 CORRELATIONS BETWEEN DIFFERENT FUELS

In the Cape there is a low negative correlation between expenditure on candles and paraffin of  $-0,21$  (Spearman Rank at 97% significance level). There is also a negative correlation ( $-0,33$  at a significance level of 87%) between the expenditure on gas and on candles and also between the amount of candles and quantity of gas used. While these correlations due no suggest the direction of substitution, from the foregoing analyses it is likely that it is from candles to paraffin and gas light.

Using non-parametric correlation analysis there are no further correlations between expenditure and consumption variables in the Cape. Using parametric analysis a weak negative correlation between the expenditure on paraffin and on electricity, and an even weaker negative correlation between expenditure on paraffin and on gas can be discerned. These cannot however be construed as evidence of shifts from one fuel to another as the underlying distributions are dissimilar.

In the Transvaal there are good correlations between the expenditure on wood and on coal at  $0,54$  (Spearman Rank) and the amount of wood and amount of coal used at  $0,49$  (Spearman Rank). This is an indication of the major role of wood as kindling for coal fires rather than as an independent fuel. There is also a correlation of  $0,34$  between the expenditure on paraffin and on wood, and of  $0,33$  between consumption of paraffin and wood. It is unlikely that this is a direct correlation and it is probable that a socio-economic variable, for instance household size, may be influencing both variables equally.

The absence of any correlations between electricity and the transitional fuels - gas, coal and paraffin, is noteworthy. In the light of the strong correlations revealed at the macro-level in chapter 5 these would be expected. In terms of the generally accepted model of energy transition good correlations between the transitional fuels themselves would also be expected. These are also not evident. All of this points to a gulf in the theory between micro- and macro-economic levels.

### 7.4 CORRELATION OF FUEL EXPENDITURE WITH SOCIO-ECONOMIC VARIABLES CAPE STUDY

#### 7.4.1 Correlation Matrix

The correlation matrix between the major socio-economic variables and the fuel expenditure variables, for the Cape and the Transvaal, is tabulated below. As fuel expenditure and fuel consumption are related the patterns described below hold for the relationships between the latter and the socio-economic variables. The expenditures on fuels are aggregated into two categories. The "major fuels" category consists of paraffin, gas and electricity or coal (with wood). The "all fuels" category includes major and

minor fuels, the latter consisting of candles, car batteries and dry batteries.

The results of the correlation analysis are as follows:-

- i) The variables time urbanized and household size have the most influence on the individual fuel variables, and also on aggregate expenditures on major fuels.
- ii) Income appears to have no significant correlation with the fuel expenditure variables on their own.
- iii) Of the fuel variables electricity and paraffin are the least influenced by the socio-economic variables.
- iv) The number of buildings per site and household income are weakly correlated with the total fuel expenditure variable.

A partial correlation analysis shows that these correlations are lower once the influences of other variables are excluded.

TABLE 7.1 FUEL EXPENDITURE; CORRELATIONS WITH SOCIO-ECONOMIC VARIABLES. CAPE

		SOCIO-ECONOMIC VARIABLES					
FUEL EXPENDITURE VARIABLES		Time urbanized	H/H size	Income week	Tot H/H expend.	builds/ site	How Long*
Paraffin expend	SOC	-	,14 <sup>a</sup>	-	-	-,14 <sup>a</sup>	-
	PPM	-	-	-	,19 <sup>a</sup>	-	-
Gas expend	SOC	,43	,27	-	-	-	,38
	PPM	,47	,24 <sup>a</sup>	-	-	-	,37
Elec expend	SOC	-	,34	-	-	-	-
	PPM	-	-	-	-	-	-
Candle expend	SOC	-	,20 <sup>a</sup>	-	-	,20 <sup>a</sup>	-
	PPM	-	-	-	,53	-	-
Dry Bat expend	SOC	-	-	-	-	,28	-
	PPM	,26	-	-	-	,23	-
Major fuels exp	SOC	,36	,28	,25	,30	,16	,41
	PPM	,44	,34	,20	,25	,25	,26
All fuels exp	SOC	,35	,28	,24	,20	,14	,32
	PPM	,39	,31	,17	,18 <sup>a</sup>	,19	,17

- NOTE. 1. Significance levels +95%, except a - 90% to 95%  
 2. Major fuels are paraffin, gas and electricity  
 3. SOC - Spearman Rank C.C. PPM - Pearson Product moment  
 4. \* How long at present address

The correlation matrix for the Transvaal is tabulated below. As the sample set is small only Spearman rank correlation coefficients were calculated.

TABLE 7.2 FUEL EXPENDITURE; CORRELATIONS WITH SOCIO-ECONOMIC VARIABLES. SPEARMAN RANK CORRELATION COEFFICIENTS. TRANSVAAL

FUEL EXPENDITURE VARIABLES	SOCIO-ECONOMIC VARIABLES					
	Time urbanized	H/H size	income week	Tot H/H expend	builds/ site	How long
Paraffin expend	-	,31	-	-	,21 <sup>a</sup>	-
Gas expend	-	-	-	-	,61	-
Wood expend	-	-	,27	-	-	-
Coal expend	-	,24 <sup>a</sup>	-	-	-	-
Candle expend	-	-	-	-	,25	-
Dry Bat expend	-	-	,53	-	-	-
Major fuels exp	,21 <sup>a</sup>	,27	-	-	,24	-
All fuels exp	,22 <sup>a</sup>	,21 <sup>a</sup>	,26	-	-	-

NOTE. 1. Significance levels +95%, except a - 90% to 95%.

2. Major fuels are coal, wood, gas and paraffin.

The pattern here is different to that in the Cape. The environmental variable, the number of buildings per site, is the most important, followed by household size. The variable time urbanized has no influence on the individual fuel variables and the correlations with the aggregates are not all at high levels of significance. The differences in the sample sizes and the wholly informal nature of the Transvaal area under study may partially explain these differences.

The influence of each socio-economic variable is now considered in more detail.

#### 7.4.2 The influence of the time urbanized

Both tables above indicate clearly that upon aggregation of individual fuel expenditures the strength of the correlations between the two groups of variables increases significantly. The expenditure on major fuels (the sum of the expenditures on paraffin, gas and electricity) is strongly correlated with the time away from origin in the Cape. This variable is the single most important indicator of the level of 'modernisation' which is distinct from socio-economic status. The implications of this are that as a population "modernizes" its expenditure on fuel will increase, whether or not income has increased.

In terms of individual fuels gas has the highest correlation to this variable in the Cape. It can be assumed that as a function of "modernization" the benefits of gas are perceived to outweigh the perceived danger of this fuel as described in the next section.

#### 7.4.3 The influence of household size

In the Cape household size is the variable with the widest influence on individual fuels although the correlation coefficients are low. Of the individual fuels, electricity and gas are significantly correlated with household size. In the Transvaal household size is significantly correlated with expenditure on paraffin and is the most highly correlated variable to the expenditure on major fuels. It also has a weak influence on the expenditure on coal and wood.

Household size influences expenditure primarily as a result of increased cooking requirements. Heating and lighting are a function of the number of rooms rather than number of people. This is corroborated by the fact that the fuels used for cooking, namely gas, electricity and paraffin are the most significantly correlated to household size.

#### 7.4.4 The influence of income

For the Cape as a whole income is not correlated with the expenditure on any of the major fuels. This is an extremely significant finding as the energy transition process is generally assumed to be a function of income. It is however correlated with both expenditure on major fuels and on all fuels. This relationship ranks in strength behind time urbanized, household size and total expenditure. This weak positive relationship with the expenditure on fuels in aggregate may not be causal and the covariance of the socio-economic variables should be borne in mind.

In the Transvaal income has a strong influence on the expenditure on dry batteries - a minor fuel, and this influence is carried through into the all fuels category. This effect may be explained by a likely strong relationship between income and the purchase of appliances (such as radios etc) that require dry batteries. Income also has some correlation with wood and coal with the latter not being significant.

On the basis of this evidence, the causal role generally ascribed to income in influencing expenditure (and hence consumption) on fuels cannot be supported. The limited size of the sample, the wide range of sub-groups in the population surveyed, the problem of multi-collinearity and the difficulty of collecting reliable income data should however be borne in mind. The role of income cannot thus be established with accuracy at this stage.

#### 7.4.5 The influence of total household expenditure

In the Cape total household expenditure has a strong correlation with the expenditure on candles, and a weak correlation at a low significance level with gas. Parametrically a weak relationship with paraffin expenditure is



also revealed. The correlation with total household expenditure on major fuels is higher than that for income. On the other hand the correlation with all fuels is lower.

In the Transvaal no correlations on any fuel category exist. The smaller sample may explain this in part, but the major differences with the Cape as a whole are probably due to the informal nature of the Transvaal sample.

There is a complex relationship between income and household expenditure which is better understood by the analysis of groups below.

#### 7.4.6 The influence of the number of buildings per site

This environmental variable has weak correlations with the aggregate fuel categories in the Cape. In the Transvaal it ranks second after household size in influence on major fuel expenditure and has a strong influence on gas expenditure. This is in line with expectations as the Transvaal survey was in winter when heating, which is largely a function of the number of rooms, was at a peak.

#### 7.4.7 The influence of other numeric socio-economic variables

All the other numeric socio-economic variables were tested non-parametrically for correlations with the fuel variables. Few of significance were revealed. The number employees per family has a correlation of 0,28 with expenditure on electricity. The mobility variable, how long at present address, has a weak correlation with expenditure on gas in the Transvaal, but none in the Cape.

It is apparent that, taken as a whole, the Cape and Transvaal surveys do not reveal the strong relationships with income suggested at the macro-level. In particular positive relationships between income and expenditure on gas and electricity, and negative relationships between income and expenditure on paraffin could be expected. However, the influence of income on individual fuels is notably absent, as is that of expenditure. Instead time urbanized and household size are the variables which influence the expenditure on individual and on all fuels in the Cape. This suggests that the process of "modernization" is a fundamental element in the energy transition process in this area. In the Transvaal the process of modernization would appear to have progressed further and is no longer a factor. This cannot however be illustrated clearly at this stage where the basis of analysis is the entire sample. To gain further insight disaggregation of the sample into groups is necessary.

## 7.5 CORRELATIONS WITHIN GROUPS

### 7.5.1 Introduction

Grouping is a powerful technique for identifying real relationships between variables by controlling the grouping variable. The technique has an inherent drawback with small samples in that the size of the groups are a function of the total number of groups and the whole sample size. In addition equality of group sizes influences the cut-points of the groups, rather than exogeneous factors. In addition, grouped data should be interpreted with care as differences between groups do not necessarily confer causality between the grouping variables and the dependent variables. For this reason correlations within groups as well as differences between groups are analysed.

Grouping in terms of dwelling type, area groups, income and time urbanised were investigated. Many additional groups, particularly in terms of non-numeric variables, could be envisaged for analysis, but the scope of this dissertation precludes this. The minor fuels, candles, dry batteries and car batteries are not treated individually but form part of the "all fuels group". Throughout, fuel groups as defined in chapter 6.3, are dealt with, rather than cross-sample averages which distort the picture in favour of high expenditure fuels. All missing values are dealt with on a pairwise basis. Only the Cape is dealt with in this section.

In the tables below all non-parametric correlation coefficients (Spearman rank) above a value of 0,35 and with a significance level of 95% (0,05) or above are in bold. While the choice of distinguishing correlations greater than 0,35 is arbitrary, it helps to identify the most important variables.

### 7.5.2 Dwelling type groups

When groups are investigated the number of cases in each group is smaller, and correlations generally weaker, than the Cape study as a whole. The Transvaal is wholly informal and has been dealt with above.

The first grouping is on the basis of dwelling type. Formal dwellings formed one group while back-yard shacks and shacks in the informal areas formed another. The significant correlations between the formal and informal areas as a whole are tabulated in table 7.3 below.

TABLE 7.3 FUEL EXPENDITURE: CORRELATIONS WITH SOCIO-ECONOMIC  
VARIABLES: DWELLING-TYPE GROUPS. CAPE

FUEL EXPEND VARIABLES	SOCIO-ECONOMIC VARIABLES					
	time urbanized	H/H size	income week	Tot H/H expend.	blds/ site	how long
<u>FORMAL</u>	(30,2)	(6,65)	(178)	(154)	(1,9)	(10.3)
Paraffin	-	-	-	[,27]	-	-
Gas	,36 [,46]	-	-	-,39	-	,24
Electricity	-	,45	-	-	-	-
Major fuels	-	,24	-	-	-	,17
All fuels	[,29]	,21 [,27]	-	-	-	-
<u>INFORMAL</u>	(8,7)	(4,4)	(124)	(63)	(1,4)	(1,9)
Paraffin	,22	,34	[,20]*	-	-	,37
Gas	-	,39	[,56]	-,56	-	,42
Major fuels	,26	,20	,18	,35	-	,35
All fuels	,23	,26	,31 [,25]	,30	[,23]	,20

- NOTE. 1. Significance levels +95%, except a - 90% to 95%  
 2. Major fuels are paraffin, gas and electricity.  
 3. Correlation coefficients are Spearman Rank. Those in brackets [] are Pearson Product moments.  
 4. () Mean values of socio-economic variables - table 7.5 for units

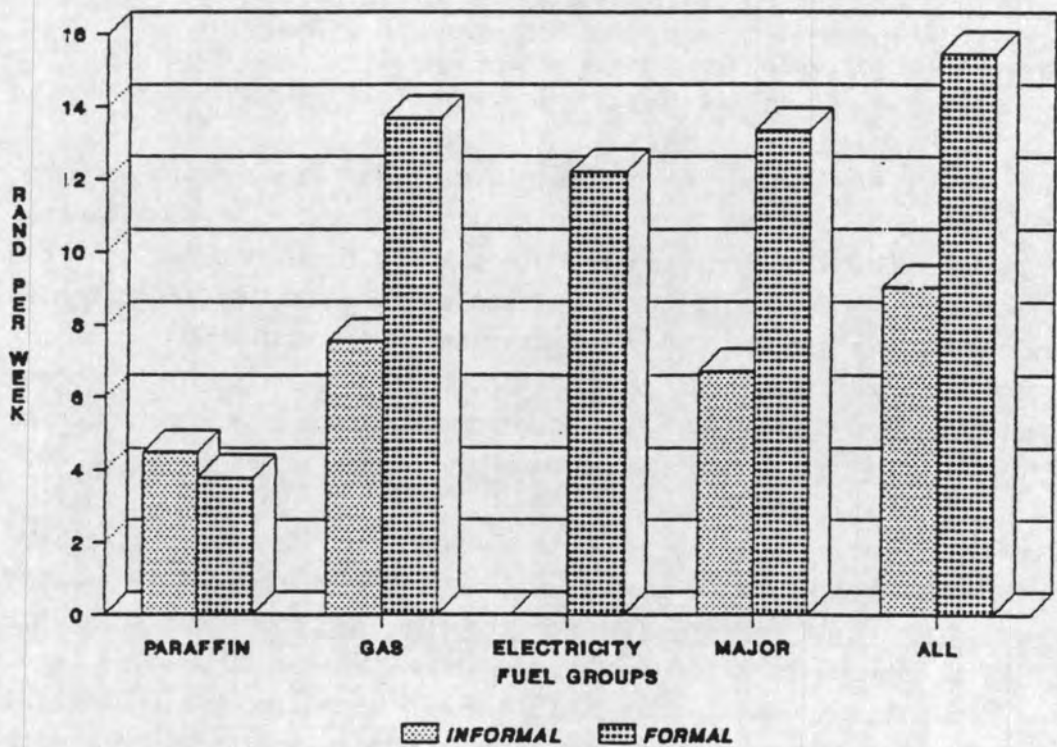
There are striking differences in the mean values of the socio-economic variables of the two groups (top line in brackets). The substantial differences in expenditure on individual and aggregate fuels between the two groups is illustrated in figure 7.1 below. These differences are fundamental to the energy transition process. Any relative shift in population from one group to the other will result in large changes in the pattern of energy demand. However, as set out below, the socio-economic variables determining fuel expenditure within each group change between the two areas under study.

In the case of the formal dwelling group time urbanized, household size and total expenditure correlate significantly with different individual fuels. Income appears to have no effect on any of the fuel groups. Total household expenditure has a strong negative relationship with expenditure on gas, suggesting a transition away from this fuel with increasing total expenditure. There is however no concomitant positive relationship with electricity as would be expected. Instead electricity is strongly correlated with family size. Why expenditure on gas should behave like this cannot be explained at this stage.

In the informal dwelling group the residential mobility variable is correlated to all the fuel variables - strongly in the case of paraffin, gas and major fuel expenditure, suggesting that fuel expenditure is strongly influenced by social stability. The mobility variable was also revealed to be important in the Transvaal which is wholly informal. A strong negative

correlation between expenditure on gas and total expenditure is revealed, similar to that for formal dwellings and is also unexplainable at this stage. Total household expenditure correlates positively with expenditure on major fuels but this is considered spurious as there are 5 electricity users in the sample with high fuel expenditures. In this group there is an indication that income plays a role. It is correlated to gas and paraffin parametrically, and with the expenditure on major fuels and all fuels non-parametrically.

FIGURE 7.1 FORMAL / INFORMAL GROUPS  
FUEL EXPENDITURE PER WEEK





From the table and figure above it appears that in terms of expenditure the most marked difference is with gas and aggregate expenditure on major and all fuels. In addition, in both groups there is a tendency for those households with lower expenditure to spend more on gas. The role of income is more pronounced in the informal areas, as found by Hughes-Cromwick (1985).

### 7.5.3 Area groups

When further broken up into old and new formal and informal areas the pattern becomes even more complex. The correlation matrix is tabulated below. Reference should be made to tables 5.1 to 5.6 that dealt with the socio-economic variables by area group.

TABLE 7.4 FUEL EXPENDITURE; SPEARMAN RANK CORRELATIONS - AREA GROUPS. CAPE

FUEL EXPEND VARIABLES	SOCIO-ECONOMIC VARIABLES					
	Time urbanized	H/H size	income week	Total expend.	builds/ site	how long
<u>OLD FORMAL</u>	(30,7)	(6,89)	(173)	(170)	(2,4)	(13,2)
Electricity	-	,41	-	-	-	-
Major fuel	-	,35	,25	-	-	-
All fuels	-	,33	-	-	-	-
<u>NEW FORMAL</u>	(24,4)	(5,23)	(166)	(115)	(1,6)	(4,0)
Paraffin	-	,35	-	-	-	-
Gas	,84	-	-	-,56	-	,53
Electricity	-	-	-	-	-	-
Major fuel	-	-	-	-	-	,32
<u>OLD INFORMAL</u>	(8,8)	(5,35)	(137)	(53)	(1,1)	(2,5)
All fuels	-	-	,30	-	-	-
<u>NEW INFORMAL</u>	(9,2)	(3,6)	(100)	(38)	(1,0)	(0,9)
Para	,42	,28	-	-	-	-
Major fuels	,37	-	-	-	-	,32
All fuels	-	,32	,35	-	-	-

NOTE: See notes Table 7.4 above.

In the old formal areas household size is the dominant socio-economic variable. It is well correlated with expenditure on electricity and on major fuels. Apart from a weak correlation between income and the expenditure on major fuels all other correlations are at low levels of significance. Noticeable by their absence are paraffin and gas. This suggests that the importance of these fuels has declined in this area group.

In the new formal areas gas has a very strong correlation with time urbanized and the mobility variable. On the other hand it also has a strong negative correlation with total expenditure. These effects appear to be contradictory

but could be explained by the adoption of gas by newly arrived residents as an interim solution and a shift away from this, probably to electricity as it becomes available or affordable.

No clear pattern emerges from the correlations in the informal areas. The lack of correlations in the old informal areas is striking. In the new informal areas the time urbanized emerges as the dominant socio-economic variable. It should be remembered that these areas house the newly established and newly migrated households with small families wherein paraffin is the sole fuel in many cases. The finding that the level of urbanization influences expenditure on fuels is significant and is investigated in more depth by grouping by time urbanized below. Also of importance is that income is correlated with aggregate expenditure on all fuels in this area group.

At this level of analysis the grouping into area groups does not clarify the energy transition process much more than the twofold division into formal and informal groups. While fuel expenditure is affected by different socio-economic variables in each area no clear pattern emerges. In some of the areas more can be inferred from the lack of correlations, such as for gas and paraffin in the old formal areas, than from the coefficients themselves. The small average size of the samples is an additional factor in reducing the confidence of interpretation.

#### 7.5.4 Income groups

To test the broad effect of income on fuel expenditure three income groups were created; namely low income - below R100/week; mid-income - between R100 and R175 per week and high income above R175 per week. The terms are relative and cut-points were determined by the need to keep the sizes of each group approximately equal.

The characteristics of these income groups are as follows:-

TABLE 7.5 CHARACTERISTICS OF INCOME GROUPS. MEAN VALUES OF VARIABLES. CAPE

VARIABLE	LOW	MID	HIGH
H/H income/wk	R55,76	132,28	282,12
Time urbanized yrs	16,7	15,11	16,23
H/H size - persons	5,18	5,47	5,95
H/H expenditure/wk	R68,76	114,18	117,00
Buildings/site	1,50	1,66	1,69
Yrs at address	6,62	5,14	6,38

While there is marked divergence between incomes the similarity in mean time urbanized is striking. Large ranges of times urbanized are thus contained

within each group. It should also be noted that family sizes are similar and increase slightly across the groups. Expenditure on fuels shows a marked increase between the low and mid-income groups but only small increases, and even decreases, between mid and high-income groups.

The significant correlations are tabulated below.

TABLE 7.6 FUEL EXPENDITURE; SPEARMAN RANK CORRELATIONS - INCOME  
GROUPS. CAPE

FUEL EXPEND VARIABLES	SOCIO-ECONOMIC VARIABLES				
	Time urbanized	H/H size	Total expend.	blds/ site	how long
<u>LOW INCOME</u>					
Paraffin	-	-	,46	-	-
Major fuels	-	-	,41	-	-
All fuels	-	-	,46	-	-
<u>MID-INCOME</u>					
Paraffin	-	,26	-	-	-
Gas	,38 <sup>a</sup>	,42	-	-	,33 <sup>a</sup>
Electricity	-	,44 <sup>a</sup>	-	-	-
Major fuels	,40	,41	-	,19	,48
All fuels	,49	,41	,26 <sup>a</sup>	,20 <sup>a</sup>	,43
<u>HIGH INCOME</u>					
Paraffin	-,33 <sup>a</sup>	-	-	-	-
Major fuels	,54	-	-	-	,26 <sup>a</sup>

NOTE: See notes Table 7.4 above.

The significant independent variable in the low income group is total household expenditure. This suggests that fuel use in this group is indeed a function of a financial variable which is expenditure rather than income.

The mid-income group is influenced by the most variables. These are time urbanized, time at present address and household size. At this stage fuel expenditure is thus determined largely by behavioural and environmental variables.

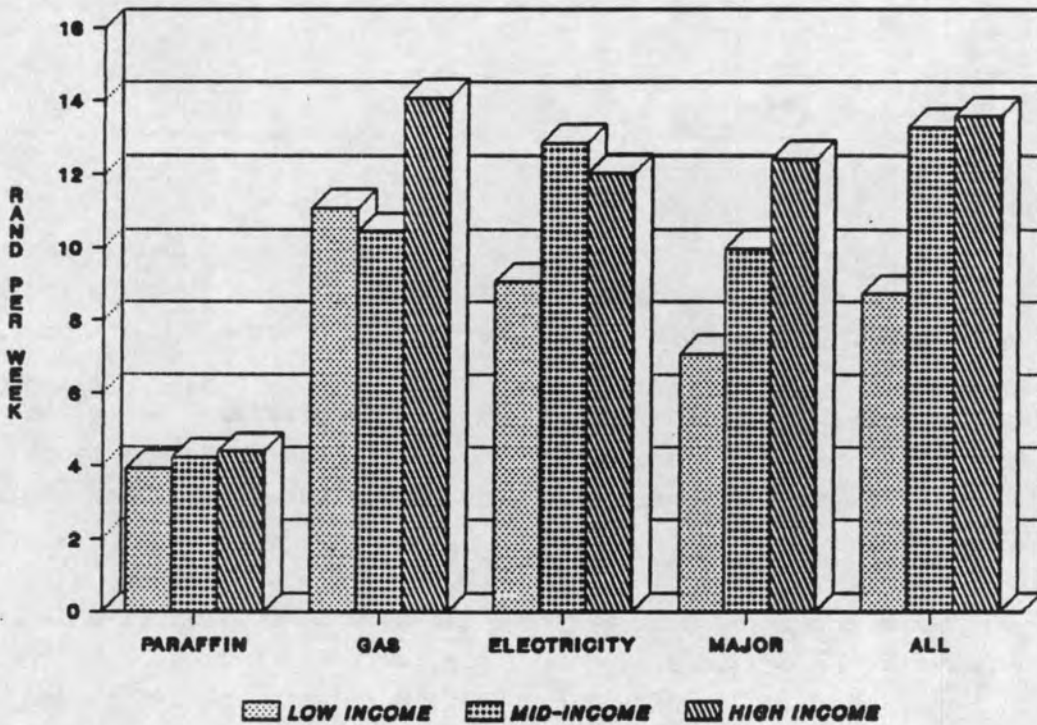
In the high-income group there is a strong correlation between time urbanized and expenditure on major fuels. In addition, although not a high level of significance there is a negative correlation between paraffin and time urbanized. The 'modernization' variable, time urbanized, is thus influential at both mid and high-income levels.

Although dependent on the reliability of the expenditure data in the low income group, these findings indicate a definite change in the variables relating to fuel expenditure as income changes.

Figure 7.2 indicates the expenditure on fuels by income group.

The energy transition process is generally seen in terms of rising incomes. The analysis by income groups indicates that there are indeed changes of individual and aggregate expenditure on fuels with rising average incomes. Within each income group however these changes are determined by different factors. In the low income group household expenditure is the key variable while in the mid and high income groups non-economic variables come into play. This suggests that the energy transition process is better conceptualized in terms of a different paradigm to the prevailing economic determinism.

**FIGURE 7.2 INCOME GROUPS  
FUEL EXPENDITURE PER WEEK**





### 7.5.5 Time urbanized groups

As seen above the time urbanized has a pervasive influence on the fuel variables, as well as on other socio-economic variables. Three groups based on time urbanized were chosen. Firstly, a newly urbanized group of those who had been in an urban area for less than 5 years. Secondly an intermediate group from 5 to 15 years urbanized and thirdly an group longer than 15 years urbanized. The cut-points were chosen on the basis of rapid urban growth during the last 5 years in the Western Cape and 15 years being approximately the span of a generation. Equalizing group sizes also influenced the choice of the cut-points. It should be noted that the groups deal with first generation migrants only. Those born in the Western Cape are excluded at this stage. The characteristics of the three groups are set out below.

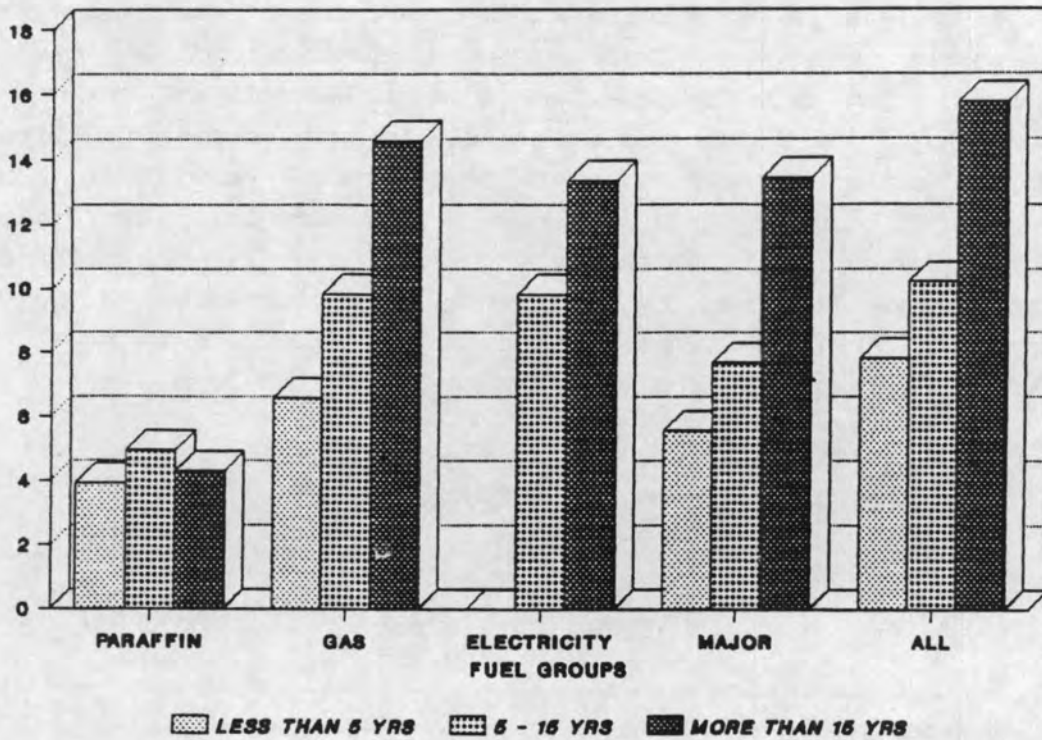
TABLE 7.7 CHARACTERISTICS OF TIME URBANIZED GROUPS. MEAN  
VALUES OF VARIABLES. CAPE

VARIABLE	LESS THAN 5 YEARS MEAN	5 TO 15 YEARS MEAN	MORE THAN 15 YEARS MEAN
Time urbanized yrs	2,15	9,92	31,76
H/H size - persons	4,95	4,50	6,64
Age respondent yrs	27,9	31,81	46,79
Income/week R	143,39	123,81	142,20

There is a marked difference in age between the three groups, in keeping with the age specific nature of rural-urban migration. In terms of income the intermediate group is the poorest while the new and old migrants are on a par.

Figure 7.3 indicates the expenditure on fuels within each fuel user group. Apart from paraffin which is relatively unchanged there is a regular increase in all the fuel groups. This regularity should be compared to the pattern for income groups above. This suggests that the time urbanized can be used as a powerful predictor of expenditure, and hence consumption of fuels. This figure relates only to expenditure within fuel groups. In terms of frequency of fuel use the first two time urbanized groups are similar while in the third group use of paraffin falls while there is a marked increase in the frequency of use of gas and electricity.

FIGURE 7.3 TIME URBANIZED GROUPS  
FUEL EXPENDITURE PER WEEK



The correlations between the socio-economic and fuel variables for these groups are tabulated below:-

TABLE 7.8 FUEL EXPENDITURE; SPEARMAN RANK CORRELATIONS - TIME  
URBANIZED GROUPS. CAPE

FUEL EXPEND VARIABLES	SOCIO-ECONOMIC VARIABLES					
	Time urbanized	H/H size	Income	Total expend	blds/ site	how long
<u>- 5 YRS URBANIZED</u>						
Paraffin	-	,36	-	-	-	,29
Major fuels	,28 <sup>a</sup>	,29 <sup>a</sup>	,27 <sup>a</sup>	-	-	,39
All fuels	,36	,34	,40	-	-	,37
<u>5 - 15 YRS</u>						
Paraffin	-	,37	-	-	-	,46
Gas	-	-	,88	-	-	-
Major fuels	-	,35	,33	,42	,26	,41
All Fuels	-	,36	,47	-	-	-
<u>+ 15 YRS</u>						
Elec	-,48 <sup>a</sup>	-	-	-	,52	-
Major fuels	-	,27	,25 <sup>a</sup>	-	,27	,36

NOTE: See notes Table 7.4 above.

In terms of the correlations at high levels of significance a pattern emerges.

In the newly urbanized and intermediate groups the expenditure on paraffin, the dominant individual fuel (frequency 100%), is influenced by household size and residential mobility. Gas, which is more frequent in the first group (25%), is not influenced by the socio-economic variables chosen. In the intermediate group where gas is slightly less frequent (22%) there is a very high correlation with household income. This is associated with a steep rise in average expenditure on gas for those using this fuel.

In the final group expenditure on electricity is correlated to the number of buildings, which is a rough measure of floorspace, but not to income. It is noteworthy that electricity emerges in the analysis as paraffin and gas disappear, the lastmentioned having no significant correlations in this group. It is also noteworthy that the influence of time urbanized and expenditure on individual fuels in all groups all but disappear.

In terms of understanding the energy transition process the correlation analysis above suggests that as the modernization process continues the environmental and behavioural variables than influence the dominant fuels are partially replaced by financial variables. The pattern is however a complex one and the role of household size and residential mobility on fuel expenditure will have to be investigated in depth over much larger samples.

#### 7.6 CORRELATION OF USEFUL ENERGY CONSUMPTION WITH SOCIO-ECONOMIC VARIABLES

When the quantities of fuel consumed are transformed to amounts of useful energy consumed, as per the transformation described in detail in chapter 6.5, the correlations with the socio-economic variables change. Candles and dry batteries are not considered as the amounts of energy supplied from these sources are tiny. The correlation matrix for the Cape as a whole and the Transvaal is tabulated below.

It should be noted that the Transvaal represents a different system in that coal is a major fuel and wood is associated with it.

It is clear that the financial variables, income and expenditure, have no influence on useful energy consumption of individual fuels in either the Transvaal or the Cape. Household size has a pervasive influence on most fuels in both areas indicating that per capita fuel consumption is important. On aggregation the variables time urbanized and residential mobility emerge as the most important in the Cape.

TABLE 7.9 USEFUL ENERGY CONSUMPTION: SPEARMAN RANK CORRELATION COEFFICIENTS. CAPE & TRANSVAAL

ENERGY CONSUMPTION VARIABLES		SOCIO-ECONOMIC VARIABLES					
		Time urbanized	H/H size	income week	Total expend.	blds/ site	how long
Paraffin	Cape	-	,16	-	-	-,15	-
	Tvl	-	,36	-	-	-	-
Gas	Cape	,34	,30	-	-	-	,31
	Tvl	-	-	-	,23	,28	-
Elec	Cape	-	,34	-	-	-	-
Coal	Tvl	,25	,28	-	-	-	-
Wood	Tvl	-	-	-	-	-	-
Total Energy Consumption	Cape	,40	,31	,22	,30	,18	,43
	Tvl	,25	,31	-	-	,23	-

The pattern that emerges is that, if measured by useful energy consumption rather than expenditure, the energy transition process is largely governed by non-economic variables. The ranking of socio-economic variables in terms of strength of correlations on major fuels is identical to that of expenditure in the case of the Cape as a whole (table 7.1).

#### 7.7 CORRELATIONS OF VARIOUS RATIOS

The ratio of expenditure on individual fuels to total expenditure on all fuels was analysed. The results were:-

i) The ratio of paraffin to total household expenditure is significantly correlated with all socio-economic variables. There are negative correlations with time urbanized (-0,40) and residential mobility (-0,39). This suggests that household expenditure on paraffin will decrease as the time urbanized increases, or if residential mobility increases.

ii) The ratio of electricity to total household expenditure is also significantly correlated to all the socio-economic variables. These are all positive, with time urbanized (0,37) and residential mobility (0,43) being the strongest.

Yet again this is an indication of a transition away from the use of paraffin and towards the use of electricity as modernization proceeds.



## 7.8 MULTIPLE FUEL USE

The analysis thus far has dealt with exclusionary fuel groups. These groups do not incorporate the multiple use of fuels which is the norm. To answer the question as to which fuels will be used as the energy transition process progresses multiple fuel use has to be addressed. Multiple fuel use groups may be classified by the characteristics of one or more objective variable. Relative expenditure or consumption of the dominant fuel are examples.

A four part grouping in terms of expenditure on the dominant fuels was used in this study as follows:-.

- 1) Paraffin Group - over 75% of total fuel expenditure on paraffin.
- 2) Gas Group - over 75% of total fuel expenditure on gas.
- 3) Electricity group - over 75% of total fuel expenditure on electricity.
- 4) Mixed group - use of multiple fuels: residual of above groups.

The cut-points of 75% of total sample fuel expenditure are arbitrary. The result are fuel groups which are inclusionary in that all subsidiary fuels are incorporated in the group.

Figure 7.4 indicates the relative sizes of the groups. Measured in terms of proportion of the total fuel expenditure of the whole Cape sample the mixed and gas groups are the largest, followed by the paraffin and electricity groups. In terms of the number of households in each sample however the paraffin group accounts for over half the sample total. This illustrates the problem in measuring group importance in terms of expenditure alone.

**FIGURE 7.4 MULTIPLE FUEL GROUPS  
GROUP SIZES**

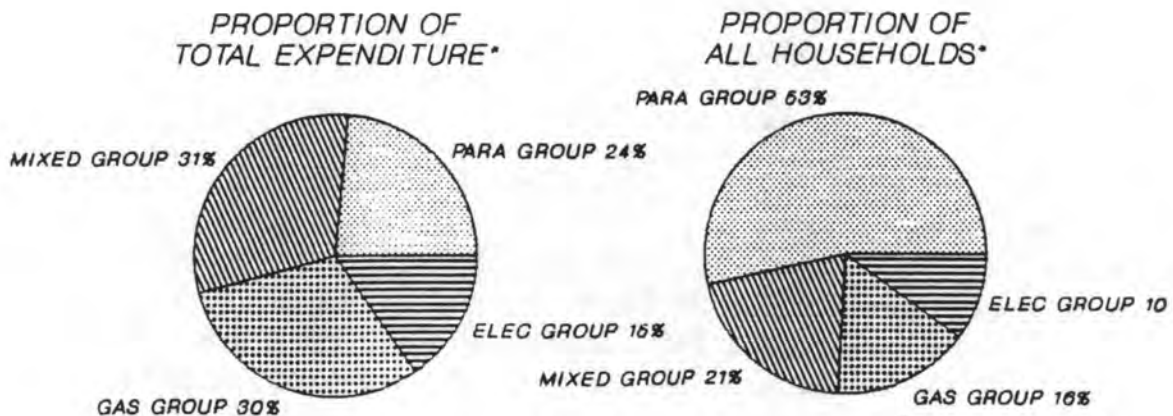
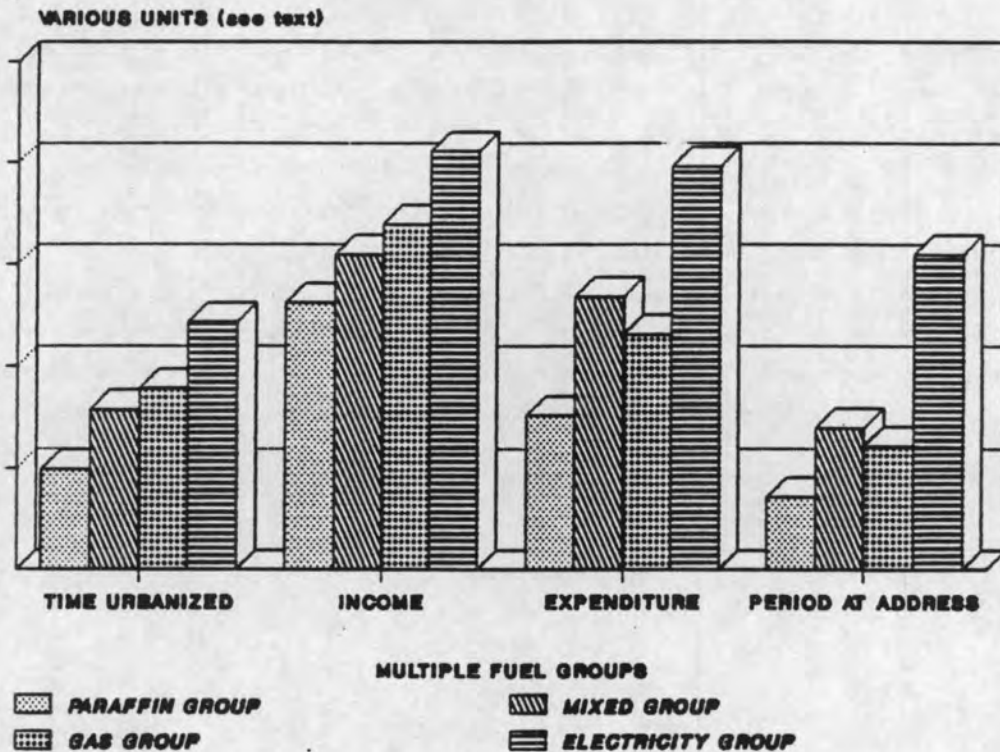


Figure 7.5 below indicates the characteristics of the four fuel groups in terms of the major socio-economic variables. It is significant that both time urbanized and income increase regularly across the four groups, indicating that these variables can be used to predict the choice of fuel group. Total household expenditure and residential mobility (period at address) are less regular with the mixed and gas groups having similar values. Household size which is not indicated varies from 5,1 persons for the paraffin group to 6,4 persons for the electricity group.

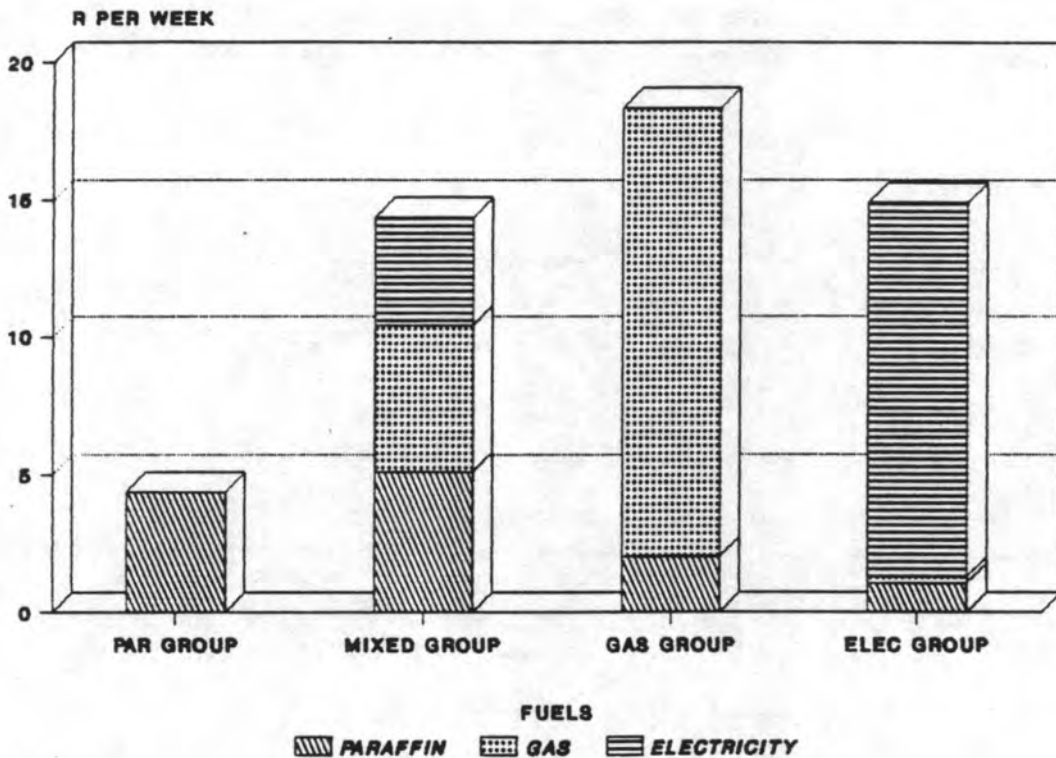
**FIGURE 7.5 MULTIPLE FUEL GROUPS  
SOCIO-ECONOMIC CHARACTERISTICS**



Each group not only exhibits a different set of characteristics in terms of the socio-economic variables but also in terms of expenditures on the dominant and subsidiary fuels as indicated in figure 7.6. In the paraffin group paraffin is the only fuel. Some 53% of the whole Cape sample thus rely on this fuel alone and on average spend R4,40 per week on purchasing it. There is a large difference in expenditure between the paraffin group and all three other groups. This suggests that the energy transition process is by adoption of new fuels without the immediate abandonment of the old ones. In the case of the mixed group average expenditure on paraffin is more than in

the paraffin group. In addition gas and electricity are purchased for similar amounts to give a weekly expenditure on all fuels of R14,37 in the mixed group. The gas group, where gas is the dominant fuel, has the highest average weekly expenditure of R18,76, followed by the electricity group at R14,80.

**FIGURE 7.6 MULTIPLE FUEL GROUPS  
FUEL EXPENDITURES WITHIN FUEL GROUPS .**



The question now arises as to how well the choice of the different multiple fuel groups can be predicted. Discriminant analysis is one method where groups are identified in terms of a number of variables. For the Cape sample discriminant analysis was carried out using the major socio-economic variables - time urbanized, household size, income and number of buildings.

The results of this analysis are set out below:-

TABLE 7.10 RESULTS OF DISCRIMINANT ANALYSIS

GROUP	% CORRECT
Paraffin	70
Electricity	50
Mixed	27
Gas	18

Additional variables and different variables were tested but no improvement on the above was apparent. It is apparent that the prediction of choice between multiple fuel uses groups, and hence individual fuel usage, on the basis of the grouping and the discriminating variables chosen is poor. The problem areas are the gas and mixed groups. Different variables not obtained in the survey that highlight consumer preferences, an important element in choice between fuels, discussed in the next chapter, will have to be found.

## 7.9 REGRESSION ANALYSIS

Regression models are the standard econometric tool for modelling energy demand. Several multiple regression models were run with total energy expenditure and useful energy consumed as the dependent variables and various The results are tabulated below.

TABLE 7.11 RESULTS OF MULTIPLE REGRESSION MODELS

AREA	DEPENDENT VAR.	INDEPENDENT VARS	R <sup>2</sup>
ALL CAPE	Energy Expenditure	Time urban., H/H size, Income, no buildings	0,27
All CAPE	Useful Energy Consumption	ditto	0,29
FORMAL	Energy Expenditure	Time urban., H/H size Income	0,13
FORMAL	Useful Energy Consumption	Time urban., H/H size	0,13
INFORMAL	Energy Expenditure	Time urban., H/H size, Income, no buildings	0,14
INFORMAL	Useful Energy Consumption	Time away, H/H size, Income, no buildings	0,20

Given the large scatter of data the low R<sup>2</sup> figures achieved are not surprising. The higher figure for the Cape as a whole suggest that larger sample sizes will benefit this technique. Ridge regression analysis on the independent variables indicates no stabilisation as theta increases,



suggesting that the ordinary least squares assumption does not hold and non-parametric techniques may be more suitable. It should be noted that operational econometric models can operate with  $R^2$  in the region of 0,55 (eg Erickson & Spann, 1973) and thus multiple regression may be the basis for models based on larger samples.

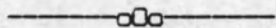
#### 7.10 CONCLUSIONS

From the examination of the relationships between the fuel and socio-economic variables it is apparent that the patterns revealed are complex. The multi-collinearity of the socio-economic variables is partly the cause. The small sample sizes and the limitations of using mainly non-parametric techniques reduce the clarity with which relationships can be distinguished even further. In spite of this a fundamental conclusion, that fuel expenditure is not generally influenced by income, may be drawn. Fuel expenditure, which is an element in the energy transition process, appears to be influenced primarily by modernization, of which time urbanized and residential mobility are two components.

Disaggregating the whole Cape sample into groups allows the examination of the behaviour of each fuel (exclusively) in more detail by controlling the grouping variable. When grouped by dwelling type the most significant variable in the informal areas is residential mobility which is a measure of social stability. When broken down further into the area groups the pattern becomes confused. Total household expenditure however does emerge as an important variable for the lower income group when grouping by income. Income itself becomes important for the newly urbanized when grouping by time urbanized. Only in the last mentioned grouping is there a pattern of increasing fuel expenditure for all fuels. Throughout all groupings household size has a pervasive influence, suggesting that per capita fuel consumption within households is an important factor. This variable should however be seen as a component of household type which is also influenced by the ages and sexes of the family as well as the sex and marital status of the household head.

The analysis of multiple fuel use is attempted by forming multiple fuel groups that are defined on the basis of the dominant fuel having more than 75% of total household fuel expenditure. A clear pattern of increasing values for all the socio-economic variables across the groups is found suggesting that the energy transition process may best be explored in term of multiple rather than individual fuel usage. The paraffin group emerges as a group solely dependent on paraffin and making up more than half the whole Cape sample. This large group can be described as the newly urbanized urban poor. The dramatic increase in expenditure between the paraffin group and all three other groups suggests that the energy transition process is one of rapid adoption of new fuels and the slow abandonment of the old ones.

From the correlation analysis it is evident that fuel expenditure can be determined by ascertaining changes in covarying socio-economic variables with varying levels of accuracy depending on the group and sample chosen. Due to the close relationship of expenditure on fuels and consumption of fuels, corroborated by the brief analysis of consumption variables and consumption ratios, it is thus possible to forecast static demand within these limits of accuracy. However, the understanding of the energy transition process requires understanding the dynamics of the choice of mixes of fuels. The brief analysis conducted indicates that this choice of fuels cannot be accurately predicted in terms of the socio-economic variables used in the study. This choice of fuels is explored further in the next chapter.



## CHAPTER 8

### ATTITUDES, APPLIANCES AND ADDITIONAL SURVEYS

#### 8.1 INTRODUCTION

In this section the attitudes of the respondents in the follow-up survey to the fuels and types of appliances used are presented. Unless otherwise stated only the Cape is dealt with. To gain further insight into fuel use four additional surveys were carried out. These were surveys of a group of woodgatherers, paraffin vendors, gas merchants and of electricity usage. A survey of fuel prices, commonly held as important determinants of fuel consumption, was also carried out for an eight year period to date.

#### 8.2 THE ATTITUDINAL COMPONENT OF THE QUESTIONNAIRE

Attitudes and preferences towards fuels shape the energy transition process but are difficult to quantify. The attitudinal component of the questionnaire consisted of three questions regarding positive and negative attitudes to fuels and preferences. This component was intended to be unstructured with the respondents replies recorded and translated at a later stage. This procedure proved to be impractical in the field and instead the replies of the respondents were recorded on the questionnaire where possible. These replies were compared to the previous question as to why each fuel was used. As the responses were dependent on the fuel used, a twofold categorisation, namely electrified and non-electrified, was used. It should be borne in mind however that multiple fuel use is the norm (see chapter 7.8) and thus attitudes to more than one fuel exist at the same time. The attitudinal response has been presented across the whole sample, with non-response included. The ranking of the results rather than the percentage values are of significance.

#### 8.3 POSITIVE ATTITUDES

The responses to the question "What do you like about the fuels you are using ?" are tabulated below.

From the answers it is apparent that it is the convenience factor involved with electricity use, rather than the cost of the fuel, that is important in the electrified group. It is also noteworthy that the economy of paraffin is on a par with that of electricity, illustrating the continued usage of paraffin within the electrified group. In the non-electrified group the dominant positive attitude is towards paraffin economy with gas cleanliness ranked a much lower second.

TABLE 8.1 POSITIVE ATTITUDES TOWARDS FUELS

ATTITUDE	ELECTRIFIED %	NON-ELECTRIFIED %
Electricity Economical	18,8	1,4
Electricity Convenient	40,6	2,8
Paraffin Economical	18,8	46,6
Paraffin Safe	3,1	2,8
Gas Economical	0	4,7
Gas Clean	3,1	15,5
No positive attitude	9,4	11,4
Non response	6,2	14,5

Electricity, in the words of one respondent, is "clean, easy and manageable" Another states, "electricity is quicker but paraffin is cheaper" - which is the common perception and the use of paraffin in the electrified group is basically to reduce the monthly electricity bill. The attitude towards paraffin is that it is "right and cheap for me" and "the right price for me".

The widespread usage of paraffin is thus as a result of its perceived economy - a perception that is not borne out by the analysis, in section 6.6, of fuel costs in terms of useful energy wherein electricity, gas and paraffin are all found to be similarly priced.

#### 8.4 NEGATIVE ATTITUDES

The question "What don't you like about the fuels you use" ? elicited the following replies.

TABLE 8.2 NEGATIVE ATTITUDES TOWARDS FUELS

ATTITUDE	ELECTRIFIED %	NON-ELECTRIFIED %
Electricity Expensive	31,2	2,0
Paraffin Expensive	0	6,7
Gas Expensive	0	7,8
Paraffin Dirty	0	12,1
Gas Dangerous	3,1	8,1
No Negative Attitude	50,0	22,9
Non-response	15,6	39,9

Clearly the expense of electricity is a dominant theme in the electrified group. This is corroborated in the electricity survey below. In the non-electrified group the dirtiness of paraffin is followed by the danger and expense of gas as the dominant attitudes.



In the words of one respondent it is the "changing of the account" (price rises) that are the problem.

### 8.5 PREFERENCES

The responses to the question "Would you prefer to use another type of fuel" ? are summarised below.

TABLE 8.3 FUEL PREFERENCES

PREFERENCE	ELECTRIFIED %	NON-ELECTRIFIED %
Electricity	21,9	32,4
Paraffin	9,4	0
Gas	0	17,6
No Preference	56,3	8,1
No Response	12,5	39,9

The high percentage preferring electricity in the electrified group can be explained by the multiple use of fuels and indicates a desire to move towards the use of electricity only. The majority have no preference for a change, indicating a high level of satisfaction - compared to the low figure for the non-electrified group. In this last mentioned group the desire to move to electricity is apparent. Also noteworthy is the preference for gas in second place.

In most cases preferences are qualified by economic considerations. One respondent felt a preference for, "electricity when I have the money", another "electricity or something cheaper". Yet another, "paraffin is the only fuel I can afford". In some cases the preference for electricity was linked to a desire for a formal dwelling. Appliances also played a role in preferences. One respondent stated, "I only have paraffin appliances", another "I have a paraffin stove".

As indicated above, preferences relate to the dominant fuel used. They also relate to satisfaction with a particular fuel. In the case of paraffin satisfaction also appears to depend on the fuel formerly used. One respondent states, "paraffin is quick and better because we don't make fire outside anymore". Another cites appliances and former fuel use, "we don't have pots to cook outside", referring to the previously ubiquitous "Driepootjie".

Cooking methods influence the preference for paraffin in combination with electricity and gas as cooking "somp" requires simmering at a low heat for extended periods - an application ideally suited to the primus stove.

## 8.6 APPLIANCES

The use of fuels is closely mirrored by the possession of appliances. The distribution of these appliances accross the whole sample is tabulated below.

TABLE 8.4 DISTRIBUTION OF APPLIANCES

APPLIANCE	% TOTAL HOUSEHOLDS
Stoves	100
Light	100
Iron	74
Heater	57
Radio	52
HiFi/tape	35
TV	33
Fridge	20

The distribution of appliances is tabulated below.

TABLE 8.5 APPLIANCES BY FUEL TYPE - % TOTAL SAMPLE

	STOVES %		LIGHT %		FRIDGE %		HEATER %
Elec	15,0	Elec	20,7		17,2		6,1
Par	52,2	Par	43,3		0		49,4
Gas	8,3	Gas	1,1		2,8		2,7
Elec+par	2,7	Candle	7,8				
Elec+gas	3,3	Cand+par	26,8				
Par+gas	18,3						
	RADIO %		HIFI %		TV %		
Elec	5,6		12,2		17,8		
Carbat	2,2		5,6		15,0		
Drybat	43,9		17,2				

It is apparent that stoves and light are basic necessities. The percentage of households owning TV's is high indicating the stature of this appliance. The percentage using fridges is low - the foodstuff distribution system in the townships reduces the necessity of this appliance to a certain extent.

The importance of paraffin as the fuel of basic necessity is apparent. It is however notably absent in the refrigeration sector. In the case of heating electrified households use paraffin heaters as electric heaters are perceived to be expensive. Slightly less than half of all TV sets are powered by car batteries.

The cost of appliances is a factor in the energy transition process. The minimum present replacement cost of various appliances is set out below.

TABLE 8.5 REPLACEMENT COST OF APPLIANCES

Primus	R20 - 25
"Beatrice" stove	35 - 45
Paraffin lamp	10 - 15
Gas 2 burner	100 - 150
Gas light	60 - 80
Gas stove	500 up
Gas fridge	900 up
Elec stove	600 up
Elec fridge	800 up

The investment required by a household using paraffin is thus an order of magnitude less than that using gas or electricity and explains in part the pervasiveness of paraffin as a fuel. The high investment in gas explains the retention of the appliances after electrification. In the case of electricity the connection and installation fees have not been considered as these are 'one-off' charges, but they are a factor for a household considering a new system.

## 8.7 FUEL VENDOR SURVEYS

### 8.7.1 Woodgatherers

The Cape Peninsula has a large wood resource in the form of woodlands of Port Jackson Willow which is a fast growing invasive species. Not only is this resource extensive but it is theoretically freely available as the removal of the species is a policy. In terms of distance however only the new informal areas of Khayelitsha, and parts of Nyanga, are within 5 kilometres of the nearest woodland. In addition, as indicated below, official policy is overridden by local constraints.

The short survey of woodgatherers was undertaken in November 1988 to ascertain some aspects of who gathered wood and what it was used for. Six woodgatherers were interviewed at a point on a bridge where they crossed back into Khayelitsha after assembling their bundles. They were part of a larger group of about 12 woodgatherers. The wood collection area was Port Jackson scrubland North of the N3 freeway.

Five of the respondents interviewed were women. Their ages varied from 35 to 60 years of age. The man was 58 years of age. All of the respondents lived in Site C Khayelitsha where they had been between 2 and 5 years. The previous addresses were given as Old Crossroads in 4 cases, Gugulethu in one and one respondent came directly from the Transkei 2 years before. Transkei was the place of origin for 5 of the respondents while the man had come some 50 years

before from the Worcester rural area. The range of household sizes was 2 to 8 persons. In all cases another member of the family was employed.

The woodgatherers had collected wood for 2 to 4 years, except in one case where the activity had begun about 6 months before. Walking to and from the wood collection area took the respondents between 1 and 2 hours each way and collecting the wood took about an hour. The man collected wood in a horsecart took an unspecified time to and from his place of sale (Athlone). The frequency of collecting trips ranged from 1 (the old lady) to 4 trips per week with the mean being 3 trips. One respondent reported doing 2 to 3 trips per day.

Generally woodgathering was seen as part of a broader activity. Three respondents were vendors of "binnegoed" (intestines and sheeps heads) and used the wood themselves for braaing this meat. Another used the wood for making Xhosa beer. Two sold the wood they collected, with the man selling it at 50 cents a bundle in Athlone which made him only R3 per week.

All the respondents used axes and collected dry wood only. The mean mass of the headloads was 12,75 Kilograms. The load on the "perdekar" was not weighed. The headloads were about 3,5 metres in length, apart from one which was 4,1m long. The circumferences of the headloads ranged from 0,75m to 1,1m. The danger of woodgathering was stressed in each case by the women who had to collect in groups for fear of being raped. The distance travelled, the danger of cars on the freeway and the difficulty of finding dry wood were other complaints. It was reported that the difficulties in collecting wood had increased due to the activities of the Traffic Police prohibiting the crossing of the Freeway other than by the bridge. Also, more seriously, it was reported that at one time woodcollecting had been prohibited and axes had been confiscated by "coloured" people in the wood collecting areas. The group interviewed claimed however that they now again had permission to collect wood.

The small number of persons using wood and the large quantities they used, as revealed in the follow-up survey, is corroborated by the evidence of this survey of woodgatherers, small though it may be. Wood is now a 'specialist' fuel and used where it imparts taste to foodstuffs. The decline in reported wood use for domestic purposes between the 2% of the follow-up survey, and the 38% reported by Eberhard (1986) for Old Crossroads could be due to the increased time of collection from this township (due to the development of Khayelitsha this area is no longer woodland) and the stiffer sanctions against collection. The destruction of Crossroads and the resettlement of its original population in a major factor in itself.

Wood is still abundant and free but the resource is hardly used. That so few households use wood could indicate a major transition away from non-commercial fuelwood. The major reason for this transition appears to be convenience although problems of collection also play a role. Unfortunately



very little prior data exists and the evidence that this transition took place is not conclusive.

### 8.7.2 Paraffin Merchants

The paraffin distribution system is a multi-level hierarchy with the top tier consisting of the oil companies who supply in bulk by tanker. Large shops form the next tier and are retailers but also act as wholesalers to the local shops (also known as "spazas") and to the "shack" shops which are dwellings that act as shops in the day.

One area was chosen for this brief survey and all those involved in the buying and selling of paraffin interviewed. The area chosen was to the north of Site B and consisted of the MH area, Greenpoint and shack areas to the west of this, as well as one centre in Khayelitsha Site B. The survey took place in November 1988 with 9 respondents.

The establishments visited were 4 dwellings, 4 small shack stores and one supermarket in a local shopping centre. The table below summarises some of the relevant data.

TABLE 8.6 PARAFFIN MERCHANTS

AREA	TYPE	YEARS OPEN	SUPPLY MODE	RETAIL PRICES				QTY/ WK
				BOT	5l	10l	20l	
Greenp	Centre	2	truck	42	2,80	5,60	11,20	160?
EC	Shop	1	truck	45			12,60	700
T Area	Shop	1	truck	45	3,15	6,30	12,15	400
T Area	Shop	1	truck	45	3,15			160
PG Area	Shop	1	truck	55				25
T Area	Shack	2 mth	truck	45	3,15			50
K Area	Shack	1 mth	collect	45				50
Greenpt	Shack	2 mth	supermkt	48				175
T Area	Shack	5 mth	local	45				20

From the table it appears that the price per bottle varies according to the size of the establishment, although one small formal shop has the highest price. Only the larger shops supply in larger sizes and these establishments sell large quantities of paraffin every week. Bottles were the most popular quantity sold at all the establishments. The larger shops also supplied paraffin appliances such as Primus stoves. The merchants estimated that their clients used between 5 to 7 bottles of paraffin per week, more in winter and

if families are large. It is apparent that the shack shops supply very small amounts and in terms of the above serve about a dozen families.

When asked what the attitude of their clientele to paraffin was it appeared that there were mixed feelings. One merchant replied, "They think paraffin is dangerous but they don't have money for other fuels". Another, "Customers believe that paraffin is the best for gas is dangerous and expensive".

The paraffin distribution system is large and pervasive. On the basis of those involved in the area surveyed several thousand merchants must operate in the Khayelitsha area alone. The suppliers are the 'formal' distributors except for the smallest of establishments and it appears that systems of credit operate at all levels. The paraffin distribution system is integrated into the formal retail system at the higher levels. The divisibility and reasonable ease of transport of paraffin are the *raison d'être* of the smaller merchants who often trade only this commodity.

### 8.7.3 The Gas Merchants

Gas is distributed widely in the black townships but the system is largely formal in comparison to paraffin. This is a result of the technology and investment required to fill gas bottles and the lack of divisibility of the fuel.

The gas survey was carried out over a wider area than the paraffin survey. It included the area covered by the paraffin survey as well as portions of Sites B and C. As with the paraffin survey formal shops, shack shops and vendors operating from home were interviewed. The survey was conducted in November 1988 and 7 establishments were visited.

The table below tabulates some of the relevant data.

TABLE 8.7 GAS MERCHANTS

AREA	TYPE	YEARS OPEN	FILL/ EXCH	KG/ WK	RETAIL PRICES RANDS					
					3kg	4,5kg	7kg	9/10kg	14kg	19kg
Site C Shop		1	F&E	600	2.30	(7,50)	5,30			
Grnpt Shop		0,5	E	350				11,65	18,10	24,50
Site C Superm		2	F&E	-	2,45	(6,65)	4,65	12,85		
T Area Shop		1	F&E	300	2,50	(6,60)		13,30	16,60	25,50
Site B Superm		1	F&E	2000				13,30	16,60	25,50
Site B Shop		0,5	F&E	200	2,20		4,95	(8,50)		
Site C Shack		1	F&E		250	2,20			4,95	12,95

A problem with data collection in this survey was the use of net and gross figures for the weight by different companies. As a result prices are not directly comparable. The 4,5 Kg bottle (nett) from one company is equivalent to a 10kg bottle (gross) of another. From the above table it appears that prices are very similar, suggesting a controlled retail price by the major gas suppliers. This may be due to the capital investment required by the gas suppliers to allow distributors to refill bottles as all except one establishment filled and exchanged gas bottles.

In reply to a question regarding their customers attitudes to gas 4 out of the five replies were that they felt gas was dangerous. On the other hand when queried as to whether they had heard of any customers having accidents all except one replied in the negative. The positive aspects of gas highlighted were its cleanliness and speed, both in relation to paraffin.

In reply to a question regarding the estimate of the amount of gas the merchants estimated each user family consumed per week the answers ranged from 2,5 kg to 7 kg, with the 4,5 kg being the approximate mean. This is somewhat less than the 7,0 kg average in table 7,5 above. This may be due to over-reporting of use by overestimating the frequency of replacement. With regard to this frequency the merchants themselves estimated that families replaced their bottles every week or second week for the smaller sizes.

## 8.8 THE ELECTRICITY SURVEY

### 8.8.1 The Sample

By courtesy of the Department of the City Electrical Engineer of Cape Town a sample was taken of 33 respondents from the follow-up survey. These were all electrified households in the townships of Langa and Gugulethu. Consumption for each month over a 2 year period was recorded, as was outstanding balance and the history of disconnections. This data was then compared to data obtained for each household from the follow-up survey.

### 8.8.2 Socio-economic profile of sample

The households in the sample had an average size of 7,55 (Std Dev 3,61), 4,38 adults and 1,98 employed per household. Some 14 of the 33 respondents were first generation urbanites with an average time urbanized of 35 years. Average income per week was R223,83 (Std Dev 120,50) and average total expenditure R181,61 per week indicating a positive average disposable income.

### 8.8.3 Consumption and cost

The average consumption per household was some 423 units per month, with a standard deviation of 160 and a range from 151 to 785 units. This figure is

well below the average of 600 for 1987/88 for Cape Town as a whole (Annual Report of City Electrical Engineer, 1987). The frequency distribution of the household consumption is shown in figure 8.1. It is apparent that the distribution is even over the 200 to 600 unit per month range. There is pronounced seasonality in the average consumption of electricity as indicated in figure 8.2. The winter peak for 1988 is about 70% up on the summer minimum.

FIGURE 8.1 ELECTRICITY SAMPLE  
Freq. Distrib. - av. monthly consumption

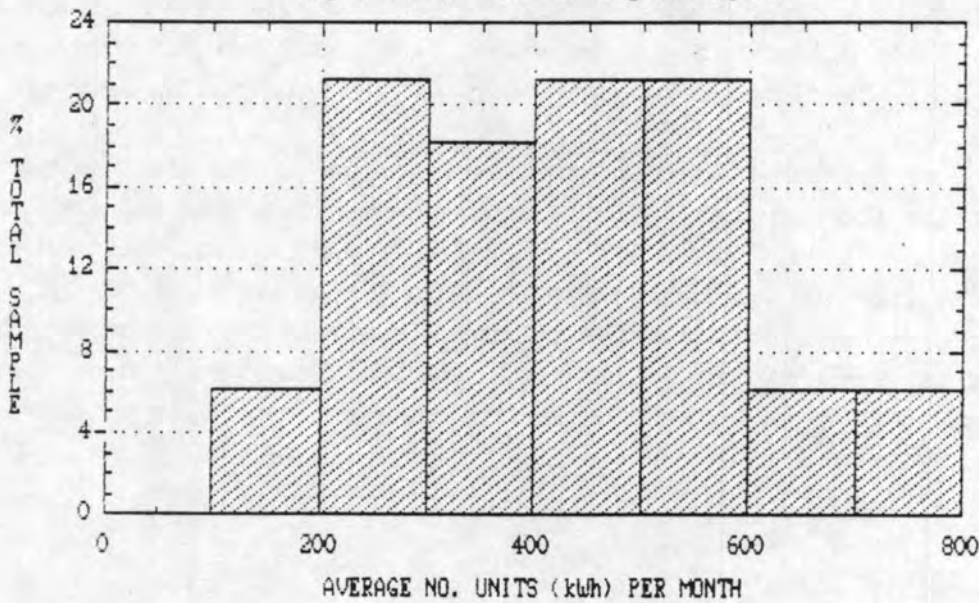
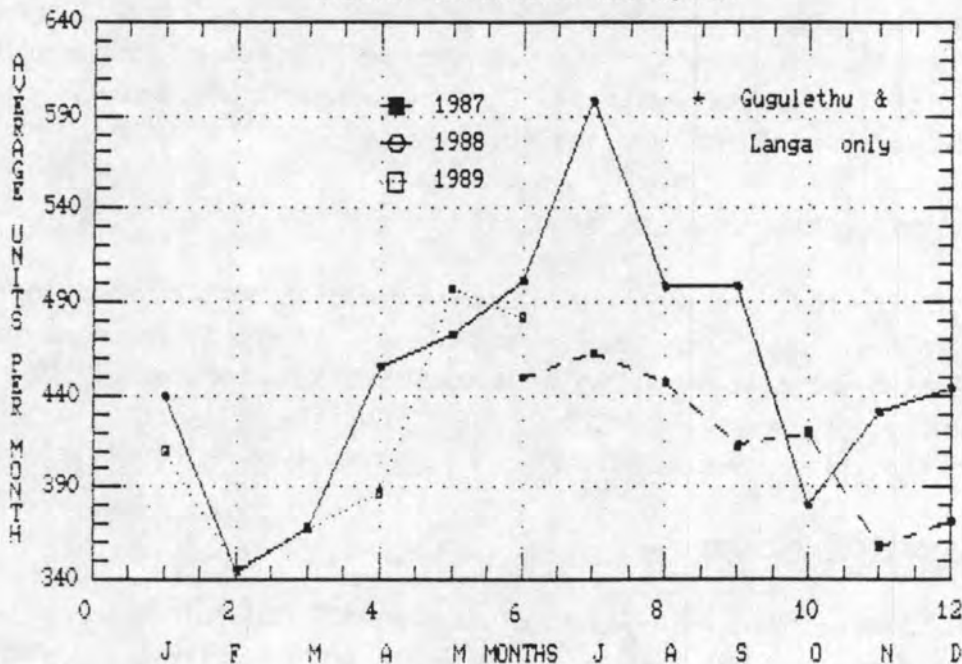


FIGURE 8.2 ELECTRICITY SAMPLE \*  
Seasonal Variation of Consumption





Three different tariffs prevailed over the period in question. The cost of electricity to each household was calculated from the tariffs and the units consumed. The average monthly cost of electricity was R40,45 with a standard deviation of R14,31 and a range from R16 to R75. The amounts are not discounted for inflation.

#### 8.8.4 Outstanding balance and disconnections

On average R676 was owing per household for electricity, with a huge range from R4 to R4993. A credit ratio of average electricity cost to the amount outstanding was calculated and ranged from 0 to 141 months, with an average of 17 months. This indicates great difficulty (or unwillingness) in paying for electricity for many households. This is corroborated by the fact that households had been disconnected 0,29 times per annum on average since 1980, with a maximum of 0,8 times per annum. Disconnections have all but ceased in the last 3 years and if this period is ignored the average number of disconnections per household per annum rises to 0,5.

#### 8.8.5 Correlations

Only non-parametric methods were judged viable due to the small sample size. Spearman rank correlation coefficients were calculated between pairs of variables as follows.

i) Average electricity cost correlated reasonably with the amount reported by the respondents. The correlation coefficient (CC) was 0,73 at 99,99% significance level (SL). This is similar to the correlation between the consumption figure any single month and the average value for the whole period. This strengthens the conviction that the data in the survey is reliable.

ii) The average consumption of electricity correlated weakly with household income, 0,25 CC at 83% SL, and with household size, 0,24 CC at 82% SL, indicating that the consumption of electricity is relatively income inelastic for the sample in question.

iii) The outstanding balance owed is inversely correlated, although weakly, with household income, at -0,29 CC at 88% SL. There is a slightly better correlation with family size at 0,30 CC at 91% SL. When household income is transformed into income per capita and income per employee the correlations improve dramatically. The outstanding balance correlates with income per capita at -0,38 CC (96% SL) and with income per employee at -0,39 (96% SL).

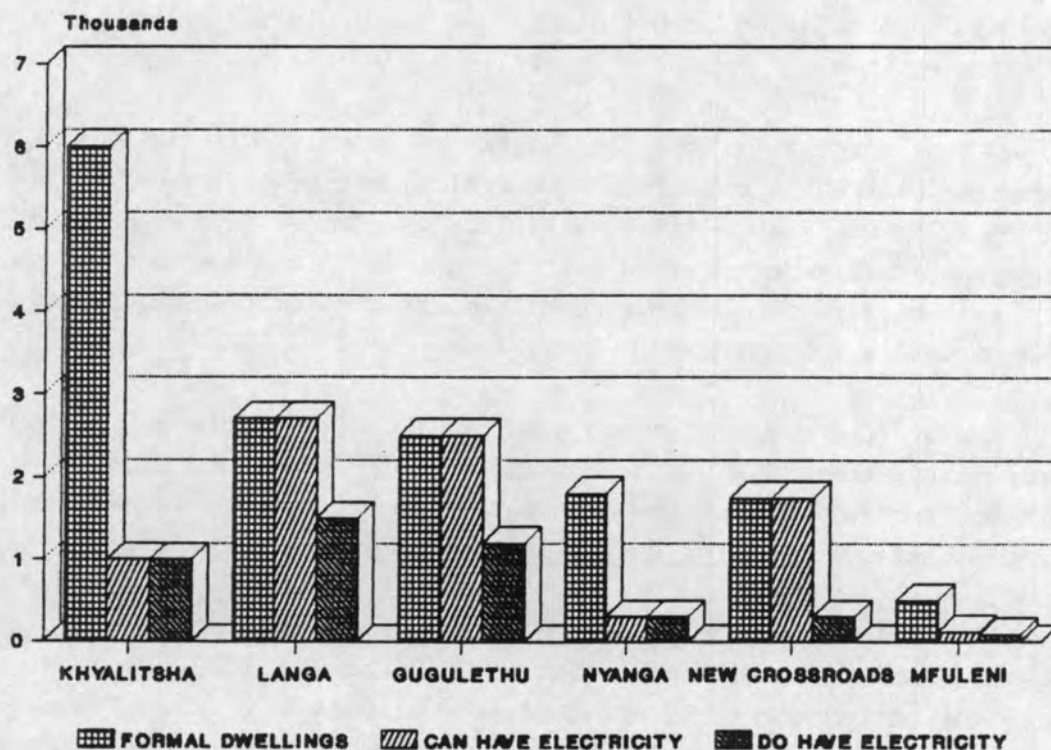
iv) There is a correlation coefficient of 0,41 (98% SL) between expenditure on electricity and expenditure on all fuels (including electricity). This compares with 0,51 (97% SL) for paraffin for the sample.

### 8.8.6 Electricity survey conclusions

From the evidence gleaned from the sample it appears that income does not determine electricity consumption. However, had the sample been broader, income may well have an effect, as the lower than average consumption figures for this area suggest. At present it appears that rather than income it is the debt burden in the form of the outstanding balance owed that is income elastic.

It appears that the transition to electricity is by no means complete. The households in the sample generally use a number of fuels with the ratio of electricity cost to total energy ranging from 17% to 100% with the average at 66%. The frequency of disconnections and hence anticipation of an interrupted service may explain this in part. The desire to reduce the total energy cost while maximising convenience is a further factor. Figure 8.3 indicates the availability and usage of electricity in the black townships of Cape Town with the low usage rates in Langa and Gugulethu standing out.

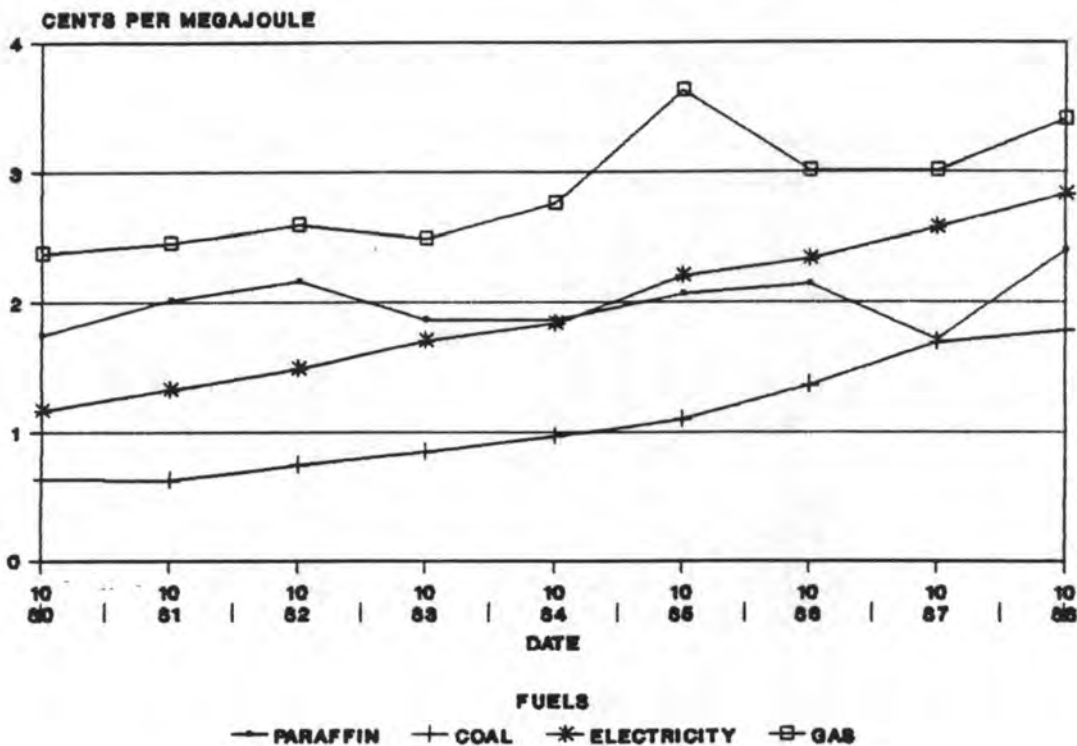
FIGURE 8.3 BLACK DOMESTIC ELECTRICITY  
AVAILABILITY, CAPE TOWN, APRIL 1988



### 8.9 PRICE SURVEY

An analysis of the price increases of illuminating paraffin, liquid petroleum gas, coal and electricity since 1970 was undertaken. Wholesale prices only were available - in the case of LPG for resellers. In the case of coal pithead prices for grade D coal was added to the cost of transport to Cape Town. Figure 8.4 illustrates the changes in useful energy prices in cents per megajoule of the four major fuels over an eight year period. The transformation to useful energy prices is as before. The cost of electricity in the black townships is understated as a 9% to 12% surcharge prevailed in 1986 to 1988. In addition the service charge for electricity was not included which would increase the overall price.

FIGURE 8.4 USEFUL ENERGY PRICES  
WHOLESALE AT CAPE TOWN, 1980 - 1988



The figure indicates that the ranking of fuels in terms of decreasing wholesale prices is LPG, electricity, paraffin and coal. A comparison with table 7.10 above indicates the effect of the distribution system on prices is substantial. For instance coal is the cheapest fuel on a wholesale basis but once bagged and distributed the price doubles to some 3 c/MJ retail at present. Paraffin also increases to a range between 3,1 and 3,7 c/MJ.

The figure is useful for establishing short term trends. It appears that this trend is for the price of LPG and paraffin to increase at a lower average rate than electricity or coal. This is unlikely to continue with the weakening Rand and inevitable increase in oil prices. A future change in fuel price ranking will in itself have an impact on the energy transition process.

No volumes of liquid fuels sold in South Africa are publicly available in terms of the Strategic Minerals Act. Hence own price elasticities cannot be calculated.

#### 8.10 CONCLUSIONS

The survey reveals a positive attitude towards the convenience of electricity and the economy of paraffin. Conversely negative attitudes towards the expense of electricity, the dirtiness of paraffin and the danger of gas prevail. While not necessarily so paraffin is perceived as being the cheapest fuel.

In terms of appliances, lighting and cooking appliances are universal while the ownership of fridges ranks lowest. In terms of cost there is an order of magnitude between the investment required for paraffin appliances as opposed to gas and electrical appliances.

The short surveys of the vendors of some of the fuels used gives additional insight into the distribution networks. Wood is now used as a specialist fuel, for commercial cooking purposes, and some wood was for sale. The paraffin distribution system is large and extends from the level of the large supermarket, through the shopping centre shop down to the shack shop and individual dwelling where small amounts are bottled for sale. The gas distribution network is the most commercial, with capital investment by the suppliers and indications of retail price maintenance. The price survey indicates that the effect of the distribution system on increasing the net energy price of fuels is substantial.

The electricity survey reveals that income is not correlated with the amount of electricity used. There is however a correlation with income per capita and per employee and the outstanding balance owing, suggesting that the debt burden is income elastic.



## CHAPTER 9

### THE ENERGY TRANSITION PROCESS AND CONCLUSIONS

#### 9.1 INTRODUCTION

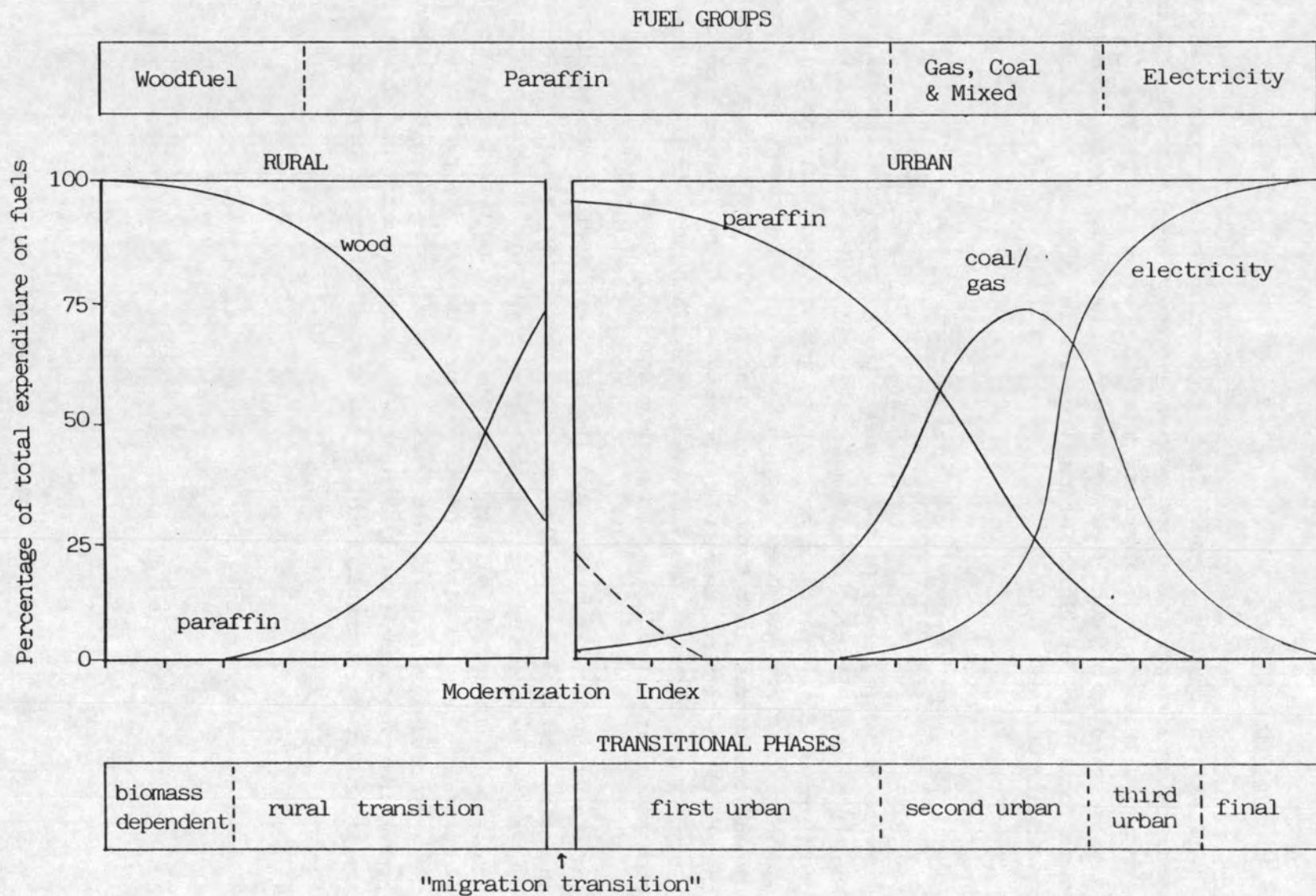
The objective of this section is to synthesize the foregoing analyses, to describe the energy transition process in South Africa and to discuss the policy implications of the process prior to drawing conclusions. It should be born in mind throughout that the comments hereunder refer largely to the black population of South Africa who are in the earlier stages of the transition process.

#### 9.2 THE DOMESTIC ENERGY TRANSITION PROCESS

From the foregoing analyses the domestic energy transition process seen as a whole is one of the complete substitution of biomass fuels and the progressive adoption and abandonment of transitional fuels before the final stage of complete dependency on electricity is reached. The process is dynamic and varies both temporally and spatially. The process is driven by the search for greater amenity and economy within the framework of the family budget. While certain specific variables explain part of the process it is stochastic with a variable random component.

The process can be described in terms of fuels used and the socio-economic characteristics of the population at a particular stage in the process. Figure 9.1 represents the process over time in an idealized form. The abscissa is in stages while the ordinate is in the budget shares of fuels, expressed in terms of either useful energy provided by a particular fuel, or of expenditure on a particular fuel. It should be noted that there is a discontinuity between the rural and urban components of the process, namely the urbanization process. Each of the stages of the process is discussed below.

FIGURE 9.1 THE DOMESTIC ENERGY TRANSITION PROCESS IN SOUTH AFRICA (BLACK HOUSEHOLDS)



### 9.3 PHASES OF THE DOMESTIC ENERGY TRANSITION PROCESS

#### 9.3.1 Biomass Dependency Phase

This represents the first phase of the process in which domestic energy is derived solely from wood, dung and crop wastes and which takes place in the rural areas. In Sub-Saharan Africa the majority of the population in all countries, with the exception of South Africa, are at this stage, as indicated in chapter 4.

The rural areas in South Africa at this phase of the process are likely to be those that are isolated and solely subsistence, with little migrancy which would result in remittances, and hence no access to commercial fuels. These areas are the ones where the immediate threat of woodfuel depletion is greatest. Aron et al (1989) indicate the possible extent of this woodfuel depletion which could result in the complete diminution of the resource in 40 years.

#### 9.3.2 Rural Transition Phase

In South Africa the evidence of the 1977 BMR data for rural areas, and the later energy studies, points towards a transition away from total biomass dependency already having taken place. In the BMR data paraffin was the major commercial fuel in the then wholly rural areas of Venda, Kangwane and Bophuthatswana. Only one of the energy studies reported an expenditure on wood of greater than 50% of the fuel budget. The problem is however the concealment of the importance of woodfuel by the non-commercial nature of this good. Woodfuel will remain the primary fuel of many rural subsistence households and the depletion of woodfuel resources will continue as no other 'free' substitute exists. But while the wood itself has no cost as woodfuel becomes more scarce it has to be collected from afar and the cost of transport introduces the price element. Once price is introduced comparisons on a price basis follow. Paraffin is often cheaper and preferred in terms of rapidity and convenience. This train of events is fundamentally the rural domestic energy transition process.

As illustrated in chapter 4 there appears to be a relationship between the general economic welfare of a region in South Africa, as measured by average incomes, and the usage of woodfuel. This pattern is also observed at the macro-economic level for the African countries analysed. The energy transition away from woodfuel will thus partly be a function of the improvement of economic conditions in the rural areas and the overall transition away from subsistence agriculture. Rural electrification may also play a role, but only in non-subsistence communities - due to the cost of appliances and the perceived expense of this fuel (see chapter 8). The rural population component of the country will however continue to decline in relative importance, although not in absolute numbers, as the result of rural-urban migration.

### 9.3.3 First Urban Transition Phase

Rural-urban migration, which is a component of the urbanization process, transplants the migrant into an urban situation where available fuels are both different and commercial. This stage of the energy transition process may be termed "migration transition" as it depends on a spatial relocation process that results in a discontinuity from the previous stages of the process.

As indicated in the literature survey the process in South Africa is "primary metropolitanisation" wherein migrancy occurs directly to one of the six metropolitan areas. In these areas a highly organised market for all fuels exists, both in the formal and informal areas, and access to free woodfuel is limited (see chapter 8). As a result the newly urbanised migrant will have no choice but to substitute woodfuel entirely by paraffin, or paraffin and coal, depending on the metropolitan area in question. This heavy dependence on a single fuel is characteristic of this stage of the energy transition.

This first urban transition phase of the domestic energy transition process is of great importance when rapid urbanization is taking place. However, in terms of the dynamics of urbanization (see definition chapter 1), rapid urban growth is possible where the rate of urbanization is relatively low - as in South Africa (see table of urbanization rates chapter 4). In such a case the first urban transition is still important as the relative consumption of fuels, both nationally and locally, changes rapidly.

### 9.3.4 Second Urban Transition Phase

Once established as an urban entity the migrant individual or household joins a community that as a whole is undergoing a process of modernisation that is rapid in relation to the rural environment. A part of this modernization process is the search for greater convenience and amenity from appliances and, ipso facto, from the fuels used.

This second urban transition phase is characterised by a falling rate of dependence on paraffin and the use of a multiplicity of fuels, of which gas emerges as a major fuel in terms of expenditure. This stage is complex as access to formal housing, formal employment, education and services is spatially uneven and certain areas modernize more rapidly than others.

This stage of the energy transition process is that in which the majority of black households in the metropolitan areas of South Africa find themselves. It must be stressed that in-migrants from the rural areas form a minority of "new urbanites", the majority being the result of natural increase. Existing households, and new households formed by persons born in the urban areas may also be trapped in this stage of the process as a result of limited access to formal housing, gas or electricity as well as budgetary constraints.



### 9.3.5 Third Urban Transition Phase

This phase of the energy transition process is characterised by a partial adoption of electricity and the reduction of importance of paraffin, coal and gas. As indicated in the electricity survey of Cape Town electricity accounts on average for less than half of the total useful energy of this sample. Gas is the dominant fuel at this stage but the expenditure on this fuel is not well explained in terms of the variables chosen in this study.

The rate of transition at this phase is a function of the availability of electricity which in turn is dependent on the extent and growth of the formal housing stock as electrification will probably take place only in this sector. The relative prices of gas and electricity in terms of useful energy do not appear to be a major factor in the rate of substitution. The perceived prices of each are more important but these in turn are subsidiary to the preference for electricity as a result of the greater convenience of using this fuel.

It should be born in mind that at this phase, as in the previous phase, multiple usage of fuels is the norm. Fuels are retained for specific purposes and the abandonment of fuels is likely to be a function of the average life of appliances. The cost of new (and second hand) appliances may indeed be the controlling factor in fuel substitution generally, rather than the factors relating to fuels themselves. As indicated in chapter 8 there is a huge difference in the price of paraffin and gas or electric appliances. Similarly the price of electrical appliances, plus the connection fee, may be factor in the continued use of gas found in the follow-up survey.

### 9.3.6 Final Phase

This is the phase of energy transition process wherein electricity is the only domestic fuel of importance and the quantity of electrical energy used is greater than that used in the previous stage. It should be noted that at this stage devices such as solar heating and gas stoves that break the monopoly of electricity may be installed. The net effect of these devices is however small.

A small proportion of the sample, less than 5%, were at this phase of the process. From the figures available on the status of the electrification of black townships in South Africa (Hansard 26 May 1987) it would appear that the national figure would be of this order as well.

## 9.4 THE ROLE OF MODERNIZATION

From the analysis presented in chapter 7 it is clear that the time a household has been urbanized is closely linked to the consumption and expenditure on fuels of a household. This variable can be used with others to

form an index of modernization. In this study car ownership, residential mobility, type of dwelling, TV ownership and whether born in the western Cape were combined to provide a rough modernization index. This index correlated well with useful energy consumption at 0,46 and total fuel expenditure at 0,42, both Spearman rank correlation coefficients at high levels of significance. However a vital component, education level, was not used as data on education was collected for only 20% of the sample. As a result this avenue of analysis was not pursued further. With data on these components better correlations could be expected.

While bearing the problem of multi-collinearity in mind it would appear that the role of modernization is fundamental to understanding the domestic energy transition process. The modernization process governs both the economic and non-economic aspects of energy transition. Income and expenditure depend in part on the level of modernization of the employed members of a household. These in turn set the budgetary constraints in terms of which appliances may be chosen and hence which fuels will be used. The preferences and attitudes towards these appliances and fuels are also largely dictated by the level of modernization. The modernization process thus limits the range of choices between fuels indirectly and the actual choices between fuels directly. The energy transition process should thus be seen in terms of the process of becoming more modern, rather than simply becoming more wealthy.

A reciprocal conclusion that may be drawn from this study is that instead of being treated as a dependent endogeneous variable energy consumption and patterns of use may be used to gauge the level of modernization. This confirms the view of Foley and Van Duren (1983) who state, "*The level of energy use, the kind of fuels and appliances, the nature of the supply system, are all characteristics of a particular level of development. They are, perhaps, best seen as indicators of development rather than causal factors of the deprivation and problems inherent in it.*"

## 9.5 POLICY IMPLICATIONS

### 9.5.1 Rural Energy Policy

If the process of energy transition in the rural areas is as slow as anticipated the dependence on woodfuel will continue for decades, with consequential deforestation and environmental problems. An energy policy to reduce this dependence would of necessity be part of a general programme of economic upliftment of the rural areas to speed up the transition away from subsistence. The reduction of the relative price of paraffin would also be beneficial but the improvement of the market system, and hence accessibility to this fuel, would be equally important. The potential impact of rural electrification is an unknown quantity and further research in this direction is required.

### 9.5.2 Urbanization

Urbanization is the single most important factor ameliorating the amount of domestic energy consumption of the rural sector. Rural-urban migration reduces the average total population growth of these areas from over 3,5% to under 1% per annum. Considering that each biomass dependent household consumes the equivalent of a hectare of scrub each year the total reduction of woodfuel consumption is huge. Generally urbanization is the province of national regional policy. A policy of 'positive urbanization' is ostensibly in force (see literature survey) but land availability is now the major factor in reducing the rural-urban migration rate. Energy policy will have some bearing on the rate of urbanization as rural energy policy, for instance rural electrification, will have an effect on the 'push' factors influencing rural-urban migration. A clear understanding of the early stages of the energy transition process will facilitate energy policy formation.

### 9.5.3 Urban Energy Policy

In terms of the dynamics of the energy transition process it is in the urban areas that energy policy can have the largest impacts. The major policy instruments that could be considered are:-

#### i) Domestic fuel price independence.

The price of illuminating paraffin is now coupled to the change in price of diesel, ostensibly as the result of mixing of diesel and paraffin when the price of the latter was low. As this is nationally the dominant domestic fuel in terms of numbers an independent pricing policy is urgently required. This pricing policy should be formulated in terms of the acceleration of the rural energy transition process and the decrease in energy costs of the urban poor. The relative pricing of domestic coal and illuminating paraffin may be the key to a change away from coal for space heating, with a consequential reduction of the extremely severe smoke pollution problem in the townships of the highveld. The influence of the differential costs between coal-braziers and paraffin heaters will also have to be investigated in depth.

#### ii) Energy policy for formal housing.

The electrification of the black townships is proceeding with the reticulation of existing and new areas of formal houses. Energy consumption may be changed with a coherent set of guidelines for the construction of energy efficient houses, the design of kitchens to allow multiple use of fuels, installation of pre-payment meters, etc.



iii) Energy policy for informal housing.

As the informal housing sector is growing at some two to four times that of the formal housing sector a coherent energy policy for this sector is essential. Planning guidelines to allow "spaza" shops in these areas are necessary as the distribution of paraffin, and to some extent gas, is through these outlets. The electrification of informal areas requires urgent attention. The economics of the exercise, the standards desirable and the methods of payment all need to be investigated.

iv) Lease / loan of appliances

As the price of appliances influences the domestic energy transition process a policy of leasing or loaning appliances should be investigated. The tradition of leasing gas ranges in local authorities supplying gas is well established, although discouraged these days. LPG appliances could be made available from local authorities on a far cheaper basis than hire-purchase.

v) Technical assistance to black local authorities.

Electricity sales generate an appreciable proportion of the revenue of many black local authorities. A policy to stimulate technical assistance of the electricity departments of these black local authorities by their white counterparts, ESCOM, government departments and the private sector, could be invaluable. In addition an urgent necessity exists for new electricity consumer education in the black townships.

## 9.6 FINAL CONCLUSIONS

### 1. Data

With respect to the data collected at the micro-level in this study it is apparent that the sample is too small. Larger samples would improve levels of confidence and permit the use of parametric techniques. In addition larger samples would permit grouping and sub-grouping to be performed with sub-samples of reasonable sizes. The lack of data on educational levels is a major drawback and more data is required that relates to the household budget, such as levels of saving. In short better experimental design is required to achieve higher accuracy in the results.

### 2. Scope

This study focusses on the domestic energy transition of black households (in South Africa). Much can be learnt about the final phases of the process by broadening the base to include other population groups, particularly the



coloureds, as they have urbanized recently and generally live in formal electrified dwellings.

### 3. Urbanization

South African urbanization as a type is akin to African urbanization generally. In spite of this the governing paradigms regarding this process are still Eurocentric. The "backwash urbanization" of Mabogunge (1986) could be used to explain the absorption of the urban growth by the informal sector but the vital questions as to how urbanization influences economic welfare and modernization are largely unanswered. Whether the existing high level of urbanization and economic development in South Africa will allow rapid modernization and consequently rapid domestic energy transition remains to be seen. This presupposes a shift from informal to formal dwellings and sectors whereas the opposite is occurring in the metropolitan areas.

The literature survey provides ample evidence that there is a link between urbanization and energy transition. The most profitable avenue of further research on the energy transition process is the identification and estimation of the spatial aspects of this link. Population shifts to the urban areas and natural growth are one aspect of this. The rates of movement between formal and informal areas within urban areas are another.

### 4. Macro vs Micro

From the literature survey the links between energy transition and economic development at the macro-level are clear. The clarity at the macro-level is however not carried through to the micro-level. At this latter level there is a pervasive economic determinism in the face of much evidence that non-market forces are the dominant factors. The findings of this study are similar. Here the energy transition process is found to be more easily detectable by cross-country and rural/urban comparison than at the micro-level. The problem is not simply the variability of data at the latter level but the fact that only cross-sectional data is available. However, the case of Zimbabwe with huge differences in net energy consumption between three sets of data for the same year, indicates the basic unreliability of macro data in Sub-Saharan Africa. Until this reliability improves answers will thus have to be found at the micro-level. Here again this abovementioned case indicates that elements of the energy transition may be ignored or misinterpreted from micro-level investigations if attention is not paid to detail.

### 5. The energy transition process in Sub-Saharan Africa.

The linkage of economic development, as measured by GNP per capita, and type and consumption of fuels, is revealed in the macro-level investigation of

selected African countries. It appears that the relationship between total population growth and the growth of woodfuel consumption will result in the inevitable increase in the dimensions of the "woodfuel crisis". In these countries energy transition is an urban process. The level of urbanization in these countries is positively related to the per capita consumption of paraffin and electricity, and negatively to woodfuel. The rate of urban growth is however associated negatively to the per capita consumption of electricity. The implication, that burgeoning cities cannot keep up with the requisite rate of electrification applies equally to the South African experience.

#### 6. A comparison with Zimbabwe

Zimbabwe may represent phases of the energy transition process through which South Africa has already progressed and through which some regions (such as the homelands) may still have to go. Zimbabwe reveals large differences in energy consumption patterns between rural areas, high density and low density urban areas. In the high density areas, similar to the South African informal areas, electricity accounts for a 60% of the useful energy consumed by households while woodfuel still accounts for 20%. In the informal areas of the Western Cape paraffin accounts for 70% of the useful energy consumed and gas the remainder but in spite of no electricity these areas consumed on average 50% more useful energy than their Zimbabwean counterparts. This suggests that useful energy consumption is related to the level of economic development regardless of the fuels available.

#### 7. Domestic energy transition in South Africa - the existing data.

An analysis of the Bureau of Market Research (BMR) of UNISA research reports since 1977 provides a cross-sectional and time-series picture of the domestic energy transition process. For the period in question the budget shares of household expenditure of the fuel and light category were always higher in the rural areas than in the urban areas. There was a relative decline in this category over time in all the urban areas while it remained static or even increased slightly in the rural areas. In addition, when disaggregated into fuel groups, there was an decrease in the use of wood as the relative urbanity of these rural areas increased. In these rural areas paraffin was in 1977 already the dominant fuel in terms of expenditure. All of these indicate that a process of energy transition has occurred over time but that, unlike the rest of Africa, this not solely an urban phenomenon. The largely static rates of fuel and light budget shares in the rural areas suggest that the energy transition process there will be a long term process in relation to the urban areas.

When dealing with these urban areas the BMR data indicates that there is a clear pattern of an inverse relationship in the average expenditure on

paraffin to that on coal. As a result South Africa can be divided into a coal dominant region, a paraffin dominant region and an intermediate region where wood is still important. Although last available for 1972 for the Cape a disaggregation of expenditure by fuels and end use indicate that at that date wood was already a minor fuel and paraffin was dominant. Comparing this data to that of the follow-up survey the domestic energy transition in this area has been from coal to gas while paraffin has remained the dominant fuel.

The BMR reports and various energy studies indicate that multiple fuel use is the norm and this is corroborated by the follow up survey. The energy studies, largely conducted in the rural areas, indicate that multiple fuel use extends to the rural areas where wood now forms between 20% and 50% of the household fuel budget. This indicates that a major transition to commercial wood purchasing has taken place but no rate of substitution can be calculated.

#### 8. The socio-economic data of the follow-up survey.

The findings relating to the socio-economic characteristics of the sample populations of the follow-up survey are in many ways as important as those relating to fuel. Differences in age, household size, time urbanized, and other characteristics indicate a fundamental difference in function between the new and old formal and informal areas. The new informal areas that are the fastest growing are the catchment areas for both newly arrived rural-urban migrants and the overflow from the old formal areas. These wide differences in characteristics and function permit the regrouping of the sample but the correlations between most of the socio-economic variables reveal that multi-collinearity prevents the isolation of the influence of a single variable. Much more research is required to unravel the effects of these variables on each other.

#### 9. The fuel data of the follow-up survey.

A much greater usage of gas and electricity in the formal areas than in the informal areas is revealed by the study. This in itself is an indication of an incipient energy transition in the move from informal to formal. Also revealed is the difference in the budget share of fuels. In the formal areas these range between 7% and 8% while in the informal areas of the Cape and the Transvaal the range is from 18% to 22%. On the other hand the share of energy as a proportion of household income had a small range of between 7% and 10,5% with the formal areas being at the upper end of the range. This indicates that the importance of fuel is best understood in terms of total household expenditure rather than income. The non-linear relationship between income and expenditure and the influence of family size explain these differences. Both these aspects require additional research as their influence is pervasive.



The study reveals that useful energy consumption is a far more powerful analytical tool than net energy consumption. Large differences of this quantity between the areas were found. These reflect the different efficiencies of the appliance sets of these areas. Another aspect highlighted in this study is the close similarity of average costs of all major fuels when calculated on a useful energy basis. This raises the important question as to whether price plays a role in the choice between fuels.

#### 10. The interrelationship of socio-economic and fuel variables

Unlike at the macro-level no strong relationships between the fuels themselves were found, apart from between coal and wood in the Transvaal sample. This suggests that the process of energy transition does not involve the simple substitution of one fuel for another.

The heart of the analytical phase of this study is the establishment of the relationships between the socio-economic variables and the fuel variables. No simple pattern was immediately apparent, probably as the result of multicollinearity. However certain variables emerged repeatedly as different groups were formed, while others remained absent. An important finding is the lack of influence of income on fuel expenditure. This absence was most noticeable in the formal areas. The most pervasive variable is the time urbanised. When regrouped in terms of this variable there is an increase in expenditure with time urbanised for all of the fuel groups.

When dealing with fuels as groups, it is apparent that on the basis of categorization by dominant fuels paraffin is the sole fuel for over half of the Cape sample with the mixed fuel group following. This is an indication of the extremely important role that this fuel plays in the region.

#### 11. Attitudes and preferences

Electricity is seen as being convenient, paraffin as being economical and gas as being clean. Although electricity is perceived as being expensive it is the preferred fuel, particularly for those who do not have it. These attitudes and preferences are fundamental as the perceptions lead to choices of appliances and multiple fuel use, such as the general case of paraffin heating in electrified homes. As indicated the range of useful energy prices for various fuels is small and hence it appears that perceived rather than actual prices are important in the choice between fuels. The cost of appliances is another vital factor in the energy transition process. Stoves and lights, which are necessities used by all in the survey, cost less than a tenth if they are paraffin as opposed to gas appliances. Electrical appliances can cost even more. A further factor, not explored in this study, is the diffusion process with regard to appliances.



## 12. The woodgatherers and fuel vendors

The very low level of wood use in the Cape revealed by the survey is a significant finding. The survey of woodgatherers indicates that wood is now a specialist fuel for food merchants in the townships and that its use is not domestic. The survey also revealed that woodgathering was a hazardous, arduous, time consuming occupation that brought in very little revenue. In addition the theoretically free access to the undeniably extensive wood resource was in practice constrained by traffic police and land owners. In the light of these considerations it is small wonder that there has been a transition away from wood to paraffin.

The brief surveys of the paraffin and gas merchants indicate an extensive formal and informal system distributing these fuels in the black areas of the Cape and the Transvaal. This distribution system plays a major role in determining not only the access of consumers to fuels but also the final retail prices. Investigation of these distribution systems is a profitable line for further research.

## 13. The electricity survey

An additional survey of the electrified households in the Cape sample indicates that the transition to electricity is by no means complete. The households in the sample consumed on average some 30% less electricity than the average for the whole Cape. Multiple fuel use was found in over half the sample and, on average, electricity accounted for only 66% of the total fuel expenditure. That the adoption of electricity is not unproblematic is highlighted by the fact that the households in the sample were 17 months in arrears on average. A significant finding is that the income of households is not correlated with consumption. There is however a negative correlation between per capita income and the outstanding balance.

This study reveals clearly that the energy transition process does not stop with electrification. This fuel has to go through an adoption phase and the subsidiary fuels have to be abandoned before the final stage of sole dependence on electricity is reached. This study indicates that how long this takes is a function of the process of modernization rather than simply the increase in the level of income.

## 14. The domestic energy transition process

To synthesize the analysis a model of the domestic energy transition process is presented. Six phases of the process are identified - from biomass dependency through rural transition and three urban transitions to a final stage of sole dependency on electricity. The choices between fuels and increasing consumption of useful energy is explained in terms of the

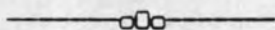
modernization paradigm presented. The level of modernization influences the attitudes and preferences towards fuels and the rate of diffusion of new appliances. It also influences the budgetary constraints of the consumer as a secondary effect through influencing income.

Within the paradigm of modernization the domestic energy transition process cannot be adequately understood outside of the framework of the household budget. While expenditure on energy increases in monetary terms as incomes rise the relative importance of this item declines. Household budgeting decisions are not well understood, especially at the lower end of the scale, but require clarification before the domestic energy transition process can be adequately modelled. Dealing with the household budget as an entity will however increase the data to be collected with consequential increased cost and complexity.

At this stage of the analysis, and with limited data, the descriptive model of the domestic energy transition process is the most complete model available. With further research socio-economic variables that correlate better with fuel choice and consumption could be found and a dynamic predictive model of the process developed. The outline of such a model is indicated in Appendix 5. The description of this hypothetical model suggests that at this stage the major improvements in quantifying energy demand are at the macro-demographic level concerning population shifts and housing.

### 13. Implications

From an understanding of the process a number of policy implications flow which are set out above. One overarching implication emerges. This is the urgent need for an urban energy policy that is part of a coherent national energy policy that considers all fuels on an equal basis.



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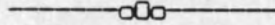
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APPENDIX 1

QUESTIONNAIRE: INITIAL SURVEY

ENERGY SURVEY

AREA

NAME OF INTERVIEWER

NAME OF HOUSEHOLD

ADDRESS OF HOUSEHOLD

	WOOD	COAL	CANDLES	PARAFIN	CHARCOAL	GAS	ELECTRICITY
A. Which fuels do you use? do you use? .....							
How much did you use last month? .....							
How much did you pay? .....							
B. Do you use it for cooking? .....							
How much do you use? .....							
What appliances do you use? .....							
C. Do you use it for heating? .....							
How much do you use? .....							
What appliances do you use? .....							
D. Do you use it for lighting .....							
How much do you use? .....							
What appliances do you use? .....							
E. Do you use it for heating water : for washing? .....							
How much do you use? .....							
What appliances do you use? .....							
F. Do you use it for ironing? How much do you use? .....							
G. Why do you use the fuels you mentioned? Cheap .....							
Convenient .....							
Available .....							
Clean / Safe .....							
Reliable .....							
Faster / Quieter .....							

A

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100

B

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100

C

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100



What electric appliances do you have? How many?

electric stove .....

9 ☐

refrigerator .....

10 ☐

electric heaters .....

11 ☐

Kettle .....

12 ☐

Iron .....

13 ☐

TV .....

14 ☐

Hi-Fi .....

15 ☐

Lights .....

16 ☐

Hot-water gyser .....

17 ☐

Other (specify) .....

18 ☐ ☐ ☐ ☐

22 ☐

How many meals do you cook per day? .....

23 ☐ ☐

How long does it usually take you to cook a meal? .....

25 ☐ ☐

For how long do you HEAT your house per day? (How many hours?) .....

27 ☐ ☐ ☐

Which months do you HEAT your house? .....

31 ☐ ☐ ☐

What time do you switch your lights on? .....

35 ☐ ☐

What time do you switch your lights off? .....

37 ☐ ☐

How many times a week do you iron? .....

39 ☐

How long does ironing usually last? .....

40 ☐ ☐

How many times a week do you heat water for washing? .....

42 ☐ ☐

How long does it take for the water to heat? .....

44 ☐

Do you collect any WOOD? .....

45 ☐

Where do you get it from? .....

46 ☐ ☐

How often? .....

48 ☐ ☐

How much do you collect each time? .....

50 ☐ ☐ ☐

What do you use it for? .....

53 ☐ ☐ ☐

What kind of wood do you use? .....

56 ☐

you use CAR BATTERIES? .....  
 w many have you got? .....  
 at do you use them for? .....  
 w long do they last before recharging? .....  
 w much do they cost to buy? .....  
 w much do they cost to recharge? .....  
 you use DRY BATTERIES? .....  
 at do you use them for? .....  
 w many do you usually buy? .....  
 w often do you buy them? .....  
 w much do they cost? .....

57

58

59

62

64

67

69

70

73

75

77

DESCRIPTION

many rooms does your house have? .....  
 (including lounge, dinning room, bedrooms, kitchen  
 toilet)  
 kind of roof does your house have? ... ..  
 (slate, iron, tiles, asbestos...) Have you added any insulation  
 to your ceiling?  
 kind of materials are the walls made of? .. ..  
 how many people live in your house? .....  
 how much money does your household earn per month?  
 .....  
 how much money do people working away from home? .....  
 how much money do they spend on goods? .....  
 how much money do they spend on services? .....  
 how much money do they receive from grants? .....  
 how much money do they receive from other income? .....

1  5

2

3

5

6

8

10

14

18

22

25

28

31

34

APPENDIX 2

QUESTIONNAIRE: FOLLOW-UP SURVEY

CODE NUMBER

TOWNSHIP/AREA.....

INTERVIEWER .....

DATE                      3. TIME                      4. WEATHER    Warm   Cold

m.....and I am doing a survey of whether people use paraffin, wood, coal or other fuels. The survey is for a project at the University of Cape Town and does not have anything to do with the Government or the Municipality.

INTRODUCTORY QUESTIONS Have you been interviewed before ? if so, when ?

Name of respondent    Mr/Mrs/Miss.....

Address of respondent              Street.....(if any)    AGE ?  
    Street No .....  
    Shack no.....

Are you the head of the household ?    

YES	NO
-----	----

    IF NOT WHO ?

How long have you been at this address ?.....Years

Where were you before that ?.....

10. From which area (homeland) did you originally come ?.....

When did you come from there ?.....

Ask them to tell you how they came to be here - where and how did they stay?

11. What is the highest grade of school achieved ?  
 HOUSEHOLD

How many people are there in your household ? (people that eat together)

2	3	4	5	6	7	8	9	10
---	---	---	---	---	---	---	---	----

18 years or older:    Male.....              Female.....

Under 18 years:        Male.....              Female.....

Number of Boarders.....

Where do the children go to school?.....

EMPLOYMENT

	Fulltime 5 days/week	Casual/ Part time	Workseeker	Pensioner
Househead				
House				
Others 1				
2				



## D. FUEL TYPE

What fuels do you use ?

Electricity	Candles	Paraffin	Gas	Wood	Coal
Charcoal	Car Batteries	Dry Batteries	Other		

### D.1 ELECTRICITY

What do you use electricity for?

Cooking	Heating water	Heating house	Light	Ironing	Other
---------	---------------	---------------	-------	---------	-------

What electric appliances do you use ?

Electric stove	Electric Geyser	Electric Fridge	Electric heater	
Iron	Radio	HiFi/Tape	TV	Other

How much does it cost per month ? R \_\_\_\_\_

Why do you use electricity ? .....

### D.2 CANDLES

Do you use candles for light ?

YES	NO
-----	----

How many per week? \_\_\_\_\_ (Number or Packets)

How much does it cost ? R \_\_\_\_\_

Where do you buy your candles ? .....

### D.3 PARAFFIN

What do you use paraffin for?

Cooking	Heating water	Heating house	Light	Ironing	Other
---------	---------------	---------------	-------	---------	-------

What paraffin appliances do you use?

Primus stove	Paraffin stove	Paraffin heater	Paraffin fridge
Paraffin lantern	Other		

How much does it cost per week? R \_\_\_\_\_

How much do you use per week? Litres \_\_\_\_\_ (AND/OR) Bottles \_\_\_\_\_

Where do you buy it? .....

Why do you use Paraffin?.....

D.4 GAS

What do you use gas for?

Cooking	Heating water	Heating house	Lights	Ironing
Other				

What gas appliances do you use ?

Gas stove	Gas heater	Gas fridge	Gas light	Other
-----------	------------	------------	-----------	-------

How much does gas cost per week ? R \_\_\_\_\_

How much gas do you use per week ? Kg \_\_\_\_\_

Where do you buy it ?.....

Why do you use gas ?.....

D.5 WOOD

What do you use wood for ?

Cooking	Heating water	Heating house
---------	---------------	---------------

Where do you make your fire ? .....

How much do you use per week ? Bundles \_\_\_\_\_ (or bags) \_\_\_\_\_ (WEIGHT)

How much does it cost per week ? R \_\_\_\_\_

Do you buy it ? 

YES	NO
-----	----

 From who ? .....

If you collect it yourself how long do you have to walk to get it ?..... Hrs

Where do you get it from ? .....

Why do you use wood ?.....

D.6 COAL / CHARCOAL (underline if used)

What do you use it for ?

Cooking	Heating water	Heating house
---------	---------------	---------------

How much do you use per week ? ..... Bags

How much does it cost per Week ? R \_\_\_\_\_

Where do you get it from ?.....

Why do you use coal / charcoal ?.....

D.7 CAR BATTERIES

What do you use car batteries for ?

HiFi	TV	Radio	Other
------	----	-------	-------

How many do you use ? 1 2 3

How often do you charge your batteries per month ?

1	2	3	4
---	---	---	---

Where do you charge them ?.....

### D.8 DRY BATTERIES

Do you use dry batteries for:  
Other.....

Torch	Radio	Tape recorder	HiFi
-------	-------	---------------	------

SIZES .....

How many do you use per week ?

1	2	3	4	5	6	7	8	9
---	---	---	---	---	---	---	---	---

How much do they cost per week ? R \_\_\_\_\_

### D.9 ATTITUDES \*get them to tell you about why and how they use fuel\*

What do you like about the fuels you are using ?.....

What don't you like about the fuels you use ? .....

Would you prefer to use another type of fuel ?.....

### E. EARNINGS PER WEEK

Under 50    50-100    100-150    150-200    200-300    300-400    400-500    More than 500

Househead

Spouse

Others 1  
2


### F. ADDITIONAL QUESTIONS

1. Do you own a car?

YES	NO
-----	----

2. Where do you work? (list).....

3. How do you travel there?

BUS	TRAIN	CAR	TAXI	WALK
-----	-------	-----	------	------

4. About how much do you spend per week on food ? R \_\_\_\_\_

5. About how much do you spend per month on clothing ? R \_\_\_\_\_

6. About how much do you spend per week altogether ? R \_\_\_\_\_

### G. DWELLINGS

1. How many buildings are On SITE

?

1	2	3	4

(size)

2. How many rooms has the main house ?

1	2	3	4
---	---	---	---

3. What are the walls of the main house made of?

Brick	Iron	Wood	Plastic
-------	------	------	---------

4. What is the roof made of ?

Iron	Asbestos	Other
------	----------	-------

5. Is there a ceiling ? YES/NO

6. Is there insulation ?

7. How many attached shacks & size ?

0	1(...rooms)	2(...rooms)	3(...rooms)
---	-------------	-------------	-------------

8. What are the attached dwellings made of ?

Brick	Iron	Wood	Plastic
-------	------	------	---------

APPENDIX 3

QUESTIONNAIRES: FUEL VENDOR SURVEYS



## QUESTIONNAIRE FOR WOOD GATHERERS; WESTERN CAPE; NOVEMBER 1988

### 0. CODE NUMBER

1. INTERVIEWER        MARY MTIMKA
2. AREA/TOWNSHIP .....
3. DATE .....
4. TIME .....

I'm Mary and I am doing a survey on various type of fuels for a project for the University of Cape Town. This does not have anything to do with the Government or Municipality.

### A. INTRODUCTORY QUESTIONS

1. Name of Respondent        Mrs / Miss .....
2. Address                    Area .....
- Street .....
- Shack number .....
3. Age of respondent ? .....
4. How long have you been at above address ? .....
5. Where were you before that ? .....
6. When did you come to Cape Town ? .....
7. Where were you born ? .....

### B. WOODGATHERING QUESTIONS

1. Do you work full time as a woodgatherer ?    YES   NO
2. What other activities do you do ? .....
3. How many years have you been working as a woodgatherer ? .....
4. Which areas have you collected wood from in the last 2 years ?  
    (Describe) .....
5. How long does it take you to walk to where you cut wood ? .....
6. How long does it take you to collect the wood ? .....
7. Do you make several trips to cut wood every day ?    How many ? .....
8. Do you cut wood ?            YES   NO
9. What do you use to cut the wood ?            AXE   SAW
10. What kind of wood do you prefer ? .....
11. What do you collect the wood for ?    HOME   SELLING
12. How many bundles do you collect -per day ? .....
- per week ? .....
13. If selling: Where do you sell it ? .....
- How often ? (daily, every other day, etc) .....
- How many bundles per day ? .....
- How much do you charge per bundle ? .....
- About how much money do you make every week ? .....
14. Who buys the wood from you ? .....
15. What problems do you have in collecting the wood ? .....
- .....

QUESTIONNAIRE FOR PARAFFIN MERCHANTS: WESTERN CAPE; NOVEMBER 1988

DE NUMBER

INTERVIEWER

MARY MTIMKA

WNSHIP

TE

ME

ME OF ESTABLISHMENT

PE OF ESTABLISHMENT

Shop in Shopping Centre

Shop

House

DRESS

ary and I am doing a survey on various types of fuels for the  
rsity of Cape Town. The Survey has nothing to do with the  
ipality or the Government and all replies are confidential.

IONS

me of respondent ?

w long has this business been located here ?

ere were you located before ?

ere do you buy your paraffin ?

In what quantities

w much does it cost ?

at are the retail prices of paraffin ?

ttle

Litre

Litre

litre

her

ich is the most popular size ?      Bottle      5L      10L      20L

n the public buy Primus stoves etc here ?

you have customers who buy in bulk ?

How many litres

you deliver ?

How ?

Where ?

o you have regular customers ?

ow much paraffin would you estimate an average family uses each  
?

here do your customers buy their paraffin appliances ?

hat are your customers feelings about paraffin ?

o you hear of customers having accidents with paraffin ?

ow many litres of paraffin do you sell per week ?

QUESTIONNAIRE FOR GAS MERCHANTS: WESTERN CAPE; NOVEMBER 1988

0. CODE NUMBER

1. INTERVIEWER      MARY MTIMKA

2. TOWNSHIP

3. DATE

4. TIME

5. NAME OF ESTABLISHMENT

6. ADDRESS

I'm Mary and I am doing a survey on various types of fuels for the University of Cape Town. The Survey has nothing to do with the municipality or the Government and all replies are confidential.

QUESTIONS

1. Name of respondent ?
2. How long has this business been located here ?
3. Where were you located before ?
4. Do you fill only or exchange gas bottles also ?
5. Is a deposit on a gas bottle necessary ?
6. What sizes of gas bottles do you fill ?
7. What are the retail prices ?
8. Which is the most popular size ?
9. Can the public buy regulators etc here ?
10. Do you have customers who buy in bulk ?
11. Do you deliver ?
12. Do you have regular customers ?
13. At what intervals do families replace their gas bottles ?
14. How much gas would you estimate an average family uses each week ?
15. Where do your customers buy their gas appliances ?
16. What are your customers feelings about gas ?
17. Do you hear of customers having accidents with gas ?
18. How many kilograms of gas do you sell per week ?

APPENDIX 4

SUMMARY STATISTICS AND STATISTICAL MANIPULATION  
OF THE DATA



## APPENDIX 4

### SUMMARY STATISTICS AND STATISTICAL MANIPULATION OF THE DATA

#### A4.1 OBJECTIVES

As the data set is reasonably large, over 500 interviews in the initial survey and 247 interviews in the Cape and Transvaal follow-up surveys, the variables numerous and the statistical transformations many the objective of this appendix is to clarify the statistical attributes of the data. Some measures of central tendency and reliability of the data are thus presented in summary form below. The analysis of the results themselves are dealt with in the body of the dissertation.

#### A4.2 THE INITIAL SURVEY

##### A4.2.1 Summary Statistics - numeric variables

The data from the initial survey was grouped into 205 variables. A few of the major numeric variables are summarised by season in the tables below. In the winter of 1987 198 interviews were carried out in the formal black areas.

TABLE A4.1 INITIAL SURVEY; WINTER 1987: FORMAL AREAS:  
NUMERIC VARIABLES.

NO	VARIABLE	CASES	MEAN	RANGE	ST ERROR	ST DEV
1	Household size	197	6,13	17	0,202	2,835
2	Total income/mth	197	368,93	1600	21,20	297,61
3	Qty paraffin ltr	171	36,4	177	2,52	31,53
4	Qty Gas kg	54	17,7	45	1,34	9,88
5	Expend paraffin R	198	12,74	92,25	1,22	17,20
6	Expend Gas R	198	5,18	60	0,80	11,30
7	Expend elect R	198	12,04	1670	1,47	20,73

In the summer of 1987/88 a total of 295 interviews were carried out. No disaggregation of 'formal' and 'informal' was carried out.

TABLE A4.2 INITIAL SURVEY; SUMMER: ALL AREAS - NUMERIC VARIABLES.

NO	VARIABLE	CASES	MEAN	RANGE	ST ERROR	ST DEV
1	Household size	295	6,32	67	0,28	4,78
2	Total income/mth	294	339,86	2000	21,68	371,73
3	Qty paraffin litres					
4	Qty Gas kg					
5	Expend paraffin R	295	8,92	80	0,79	13,60
6	Expend Gas R	295	6,72	82	0,78	13,35
7	Expend elect R	295	16,89	98	1,43	24,62

#### A4.2.2 Validity of the data - Results of the Backcheck

From the follow-up survey the validity of the initial survey could be partially checked. As the follow-up survey used the address set of the initial survey as the frame the names of households could be checked for similarity. Spellings of African names varies widely, but this was taken into account. The respondents replies to the question of whether the family had been interviewed before and the similarity of family sizes are also presented in the table below.

TABLE A4.3 RESULTS OF BACKCHECK

AREA	CASES	SAME NAME %	INTERVIEWED BEFORE			SAME H/H SIZE %
			YES %	NO %	UNSURE %	
LANGA	23	35	30	30	40	26
GUGULETHU	22	55	36	50	14	9
NYAN & NEW CR	17	82	24	71	5	29
KYA VILLAGE	35	57	37	51	12	20
KHY SITE B	19	74	47	47	6	10

From this table it is apparent that, even if allowances are made for different respondents in the same family, lapses of memory, changes of family size and movement of families a significant proportion of the questionnaires in the initial survey are of doubtful validity. This dubiety is reinforced by the visual appearance of some of the returns which appear not to have have been prepared in the field and either completely or partially falsified.

The problem thus arises in selecting which data is acceptable and which is falsified is a statistical exercise beyond the scope of this dissertation. As a result, unless otherwise indicated, the follow-up survey forms the basis of further investigation.

### A4.3 THE FOLLOW-UP SURVEY - CAPE SURVEY

#### A4.3.1 Summary Statistics - numeric variables

There are 30 numeric and 12 character variables in the primary untransformed data set from the Cape survey. Some measures of central tendency and statistical attributes of the major untransformed numeric variables of the 180 interviews that took place in the summer of 1988/89 are tabulated overleaf.

#### A4.3.2 Attributes of the data

One is immediately struck by the range of values for all the variables. This is reflected in the large standard deviations. The variation in samples sizes is reflected in the standard error which is generally smaller for larger sample sizes. The variables relating to income and expenditure (7,9-11) have however high standard errors in spite of large sample sizes. This reflects both the reality of wide income and expenditure dispersion and the expected variability of replies.

#### A4.3.3 Character variables and transformed variables

In the Cape survey some 12 character variables were assembled. These were recoded as numeric classification factors to be acceptable to the statistical program used. The numeric variables were transformed by outlier exclusion, combination and various mathematical operators to form a set of some 80 transformed variables to be used in further statistical manipulation.

TABLE A4.4 FOLLOW-UP SURVEY: SUMMER 1988/89. CAPE - ALL AREAS

PART A. NUMERIC SOCIO-ECONOMIC VARIABLES

NO	VARIABLE	SAMPLE SIZE	AVE.	MED IAN	STD DEV	STD ERR	RANGE	SKEW- NESS	KURT- OSIS
1	Age Respond	179	35,6	34	14	1,04	62	0,7	-0,06
2	Yrs @ address	178	5,9	3	8,6	0,64	50	2,7	8,3
3	Yrs left orig	135	16,3	12	15,4	1,32	66	0,98	0,06
4	Hsehold size	180	5,5	5	2,9	0,21	16	1,14	2,22
5	No adults	177	3,1	3	1,7	0,13	8	1,31	1,87
6	No employed	177	1,8	2	0,8	0,06	5	0,88	0,84
7	Income/week	177	145,11	125	97,2	7,3	499	1,33	2,28
8	Av No of cars	179	0,2		0,4				
9	Food expend wk	154	61,41	44	62,8	5,1	395	3,1	12,13
10	Cloth exp mth	117	58,68	33	67,0	6,2	395	2,7	8,80
11	All exp wk	111	113,50	75	121,1	11,5	793	2,9	11,47
12	Builds/site	180	1,6	1	1,1	0,07	8	3,1	14,64
13	Rooms/build	180	2,8	3	1,1	0,08	5	0,14	-0,53
14	No shacks	66	1,6	1	1,3	0,15	7	3,0	10,90

PART B. NUMERIC FUEL-RELATED VARIABLES

NO	VARIABLE	SAMPLE SIZE	AVE.	MED IAN	STD DEV	STD ERR	RANGE	SKEW- NESS	KURT- OSIS
15	Cost candles	68	1,59	1,2	1,4	0,17	8,45	3,5	13,86
16	No candles	68	8,9	6	9,0	1,1	58	3,8	17,06
17	Cost Para wk	166	4,18	3,2	3,0	0,2	20,5	2,3	6,75
18	Litr Para wk	166	6,96	5	5,0	0,4	34,3	2,4	7,78
19	Cost Gas wk	56	11,65	7,5	8,7	1,2	37,5	1,2	1,00
20	Kg Gas wk	58	9,52	9	7,3	1,0	31,6	1,25	1,32
21	Cost wood wk	3	1,59	17	11,9	6,9	23,8	0,33	0
22	Kg Wood wk	4							
23	Cost elec mth	32	52,73	50	18,3	3,2	72	0,72	-0,14
25	No car batts	41	1,1	1	0,3	0,04	1	3,4	10,1
26	Carbat chg wk	35	2,1	2	1,3	0,23	6,5	1,7	4,1
27	Cst drybat mth	90	3,89	3	2,8	0,29	14,1	1,7	3,4
28	Yrs schooling	39	3,8	4	2,9	0,46	9	-0,03	-1,3

Note: There were nil returns on the cost and amount of coal.

A4.4 THE FOLLOW-UP SURVEY - TRANSVAAL SURVEY

A4.4.1 Summary Statistics - numeric variables

The Transvaal survey took place prior to the Cape survey, in August and September 1988, which is winter on the Highveld. The survey covered 67 respondents and the primary set contains 23 numeric variables. The attributes of these variables are given below.



TABLE A4.5 FOLLOW-UP SURVEY: WINTER 1988. TRANSVAAL

PART A. NUMERIC SOCIO-ECONOMIC VARIABLES

NO	VARIABLE	SAMPLE SIZE	AVE.	MED IAN	STD DEV	STD ERR	RANGE	SKWE- NESS	KURT- OSIS
1	Yrs @ address	67	1,1	1	0,36	0,04	1,75	1,4	3,2
2	Yrs left orig	64	15,0	13,5	11,4	1,4	45	0,6	-0,5
3	Hsehold size	67	4,2	4	1,6	0,2	10	1,8	6,7
4	No adults	63	2,2	2	0,8	0,1	4	1,7	3,0
5	No employed	67	1,2	1	0,7	0,08	4	1,7	4,9
6	Income/week	62	209,0	175	98,6	12,5	475	0,4	0,1
7	All exp wk	59	42,7	30	33,4	4,3	190	3,2	11,8
8	Builds/site	65	1,1	1	0,3	0,04	1	2,3	3,6
9	Rooms/build	65	2,6	3	0,8	0,1	4	-0,2	0,4

PART B. NUMERIC FUEL-RELATED VARIABLES

NO	VARIABLE	SAMPLE SIZE	AVE.	MED IAN	STD DEV	STD ERR	RANGE	SKWE- NESS	KURT- OSIS
11	Cost candles	65	1,7	1,2	0,8	0,1	3,6	0,6	-0,02
12	No candles	65	1,4	1	0,7	0,1	3	0,6	-0,006
13	Cost Para wk	63	2,65	2,6	1,1	0,1	5,6	1,8	5,7
14	Litr Para wk	63	3,9	4	1,7	0,2	9	1,4	3,8
15	Cost Gas wk	16	8,4	8,7	4,6	1,1	18	1,1	2,3
16	Kg Gas wk	16	4,2	4,5	2,1	0,5	8,0	0,9	1,4
17	Cost wood wk	57	1,5	1,2	0,6	0,1	2,5	0,7	-0,4
18	Kg Wood wk	58	1,6	1	0,6	0,1	2,5	0,7	-0,5
19	Cost Coal wk	58	10,7	12	3,8	0,5	12,3	0,2	-0,5
20	Coalbags wk	58	1,9	2	0,6	0,1	2	0,1	-0,4
21	Carbatno	8	1,6	1,5	0,8	0,3	2	0,8	-0,2
22	Chargeno	8	1,5	1,5	0,5	0,2	1	0	-2,8
23	Cost drybat	39	7,09	3,7	5,2	0,8	21,2	1,4	2,2

A4.4.2 Attributes of the data

As with the Cape survey the data relating to income and expenditure shows the largest standard deviations and standard errors. The ranges of the variables are large but, in spite of the smaller sample size, the standard errors of the variables are smaller than the Cape survey.

A4.4.3 Character variables and transformed variables

Only 5 character variables were used in this survey. These were recoded as numeric variables which were in turn transformed into an additional set of variables.

## APPENDIX 5

### A HYPOTHETICAL NATIONAL MODEL OF THE DOMESTIC ENERGY TRANSITION PROCESS

A HYPOTHETICAL NATIONAL MODEL OF THE DOMESTIC ENERGY TRANSITION PROCESS

On the basis of the statistical analysis, and the description of the process an spatio-econometric model of the aggregate demand for fuels can be formulated that incorporates the domestic energy transition process. The scale of inquiry is national but output would have to be disaggregated to at least the metropolitan level to be of practical benefit.

The model would have the following components:-

i) Demographic component

The population growth rates by area would be modelled at this stage. Spatial disaggregation would be at least by major metropolitan area, homelands and other rural areas - or preferably, by magisterial district. A cohort survival model of reasonable sophistication would be adequate.

ii) Mobility and housing component

The rural-urban migration process would be modelled using a standard intervening opportunities model, with 'push' and 'pull' factorial inputs as well as a modification to allow for circular migration. An inter-urban mobility component would be necessary to indicate where within a metropolitan area new households (both migrants and existing urbanites) would be most likely to reside. The supply of formal housing would be a key variable to be predicted as the supply of informal housing would be the residual of this and the total housing demand at any point in time.

iii) Demand component

The demand for various fuel types would be on the basis of predicting probable numbers of households in the formal and informal areas in the various fuel groups. The fuel group categorisation could be according to the schema adopted in this dissertation, or by another variable. The factor inputs suggested are 'modernisation index' which includes education, family size and structure, disposable income, housing type and car/tv ownership as well as other variables. Final total demand for a fuel is mean consumption multiplied by the predicted size of the fuel group.

The description of this hypothetical model suggests that at this stage the major improvements in quantifying energy demand are at the macro-demographic level concerning population shifts and housing.





REPORT NO. GEN 138

ENERGY USE IN LOW-INCOME  
DWELLINGS IN THE WINTER RAINFALL  
AREA

FINAL REPORT

R P VILJOEN

AUGUST 1990



**ENERGY RESEARCH INSTITUTE**